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**PLANNING BOARD  
GRAFTON, MA**

**EXHIBIT 13**

**STORMWATER MANAGEMENT  
SUBMITTAL  
FOR**

**Meadowbrook Manor**

**Grafton, Massachusetts**

**PREPARED FOR:**

**Sugar Realty Trust**

**PREPARED: February 24, 2019  
Revised May 7, 2019**

**BY:**

**SUMMIT ENGINEERING & SURVEY, INC.  
710 MAIN STREET  
NORTH OXFORD, MASSACHUSETTS 01537  
JOB NO.: 18-102**

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## **WATERSHED DESCRIPTION**

The 5.69-acre watershed being analyzed is located within the limits of the Town of Grafton and consists of agricultural equestrian purposes. The 12.4-acre locus property consists of one residential building and a horse barn with associated paved driveways and other infrastructure. The site is bisected by an intermittent stream running north and south. Adjacent to this stream, on the east side is a graveled driveway leading to the horse barn. Any area west of the graveled drive is excluded from this analysis for it discharges to the stream. This stream is up gradient from the project. The applicant is proposing to widen approximately 500 feet of the existing paved driveway to access two additional residential lots. The widened driveway will be maintained as a private road pending Planning Board approval. The two residential lots will be marketed and likely developed by others. Several assumptions have been made to reflect this future development within this stormwater plan.

## **STORMWATER PLAN DESCRIPTION**

The purpose of this stormwater plan is to evaluate the existing 2, 10, and 100-year watershed discharges and the proposed 2, 10, and 100-year watershed discharges to support no increase in proposed downstream discharges. We accomplished this by analyzing the pre and post-development conditions onsite using HydroCAD, which utilizes the SCS TR-20 methodology, and storing the excess runoff from the proposed conditions in detention systems on-site and releasing the water at a rate that would not exceed the existing conditions.

## **STORMWATER RUNOFF REQUIREMENTS**

### **Existing Conditions TR-20 Analysis**

The existing drainage area was obtained by reviewing the topographic information as shown on Exhibit 2 located in Appendix 1.

The Soil Conservation Service TR-55 methodology can be used to determine the basin time of concentrations (Tc). For this analysis any time of concentration calculation yielding a time less than 6 minutes was assumed to be 6 minutes. Tc values for this analysis are summarized in Table 1.

The soil survey of Southern Worcester County (Exhibit 1) was used to determine the hydrologic soil groups for the site. The curve number calculations are included in Appendix 1 and summarized in Table 1.

**TABLE 1**  
**Existing TR-20 Hydrologic Model Sub-basin Characteristics for 2, 10, and 100-year Storms**

Sub-basin	Area (sq. ft.)	CN	Tc (minutes)	Remarks
E1	248,055	79	19.9	
Sub-basin	Peak Discharge (cfs)			Remarks
	2-yr	10-yr	100-yr	
E1	5.72	11.42	25.99	Existing Road Swale

The TR-20 hydrologic models used to simulate the 2, 10, and 100-year storm events for the existing watersheds are located in Appendix 1. The appropriate Extreme Precipitations Tables provided by the Northeast Regional Climate Center was used in conjunction with the Worcester rainfall depths for the 2, 10, and 100-year, 24-hour recurrence intervals to produce direct runoff hydrographs.

#### **Proposed TR-20 Analysis**

The proposed drainage areas are depicted on Exhibit 3. We have analyzed the proposed site as one watershed. The watershed characteristics are summarized in Table 2 and delineated on Exhibit 3 located in Appendix 2.

The Soil Conservation Service TR-55 methodology can be used to determine the basin time of concentrations and are summarized in Table 2.

The soil survey of Southern Worcester County (Exhibit 1) was used to determine the hydrologic soil groups for the site. The proposed land use will be single family residential. The proposed drainage areas are summarized in Table 2 and delineated on Exhibit 3.

**TABLE 2**  
**Proposed TR-20 Hydrologic Model Sub-basin Characteristics for 2, 10, and 100-year Storms**

Sub-basin	Area (sq. ft.)	CN	Tc (minutes)	Remarks
P1	131,932	80	18.7	Shallow concentrated flow
P2	96,650	77	12.5	Shallow concentrated flow
P3	19,473	83	6.0	Direct Entry

Sub-basin	Peak Discharge (cfs)			Remarks
	2-yr	10-yr	100-yr	
P1	3.92	7.68	17.11	To Pond 1P
P2	2.66	5.53	12.96	To Pond 1P
P3	0.82	1.51	3.20	Existing Road Swale

The TR-20 hydrologic models used to simulate the 2, 10, and 100-year storm events for the proposed watersheds are located in Appendix 2. The appropriate Extreme Precipitations Table provided by the Northeast Regional Climate Center was used in conjunction with the Worcester rainfall depths for the 2, 10, and 100-year, 24-hour recurrence intervals to produce direct runoff hydrographs.

## STORMWATER RUNOFF STORAGE REQUIREMENTS

The watershed plan storage and discharge for the site is summarized in Table 3. The site storage relationships are contained within the TR-20 analysis and the discharge relationships are calculated in Appendix 2.

The development of the site is based upon providing the construction of a detention pond. The existing and proposed peak discharges for the 2, 10, and 100-year storms are listed in Table 3. Table 4 shows no increase in peak flows caused by the proposed site improvements.

**TABLE 3**  
**Existing and Proposed Watershed Peak Discharge**

Sub-basin	Existing Peak Discharge (cfs)			Proposed Peak Discharge (cfs)			Remarks
	2-yr	10-yr	100-yr	2-yr	10-yr	100-yr	
R1	5.72	11.42	25.99	2.71	11.41	21.59	Ex. Road Swale

**TABLE 4**  
**Net Watershed Peak Discharge**

Sub-basin	Net Peak Discharge (cfs)			Remarks
	2-yr	10-yr	100-yr	
R1	-3.01	-0.01	-4.40	Existing Road Swale

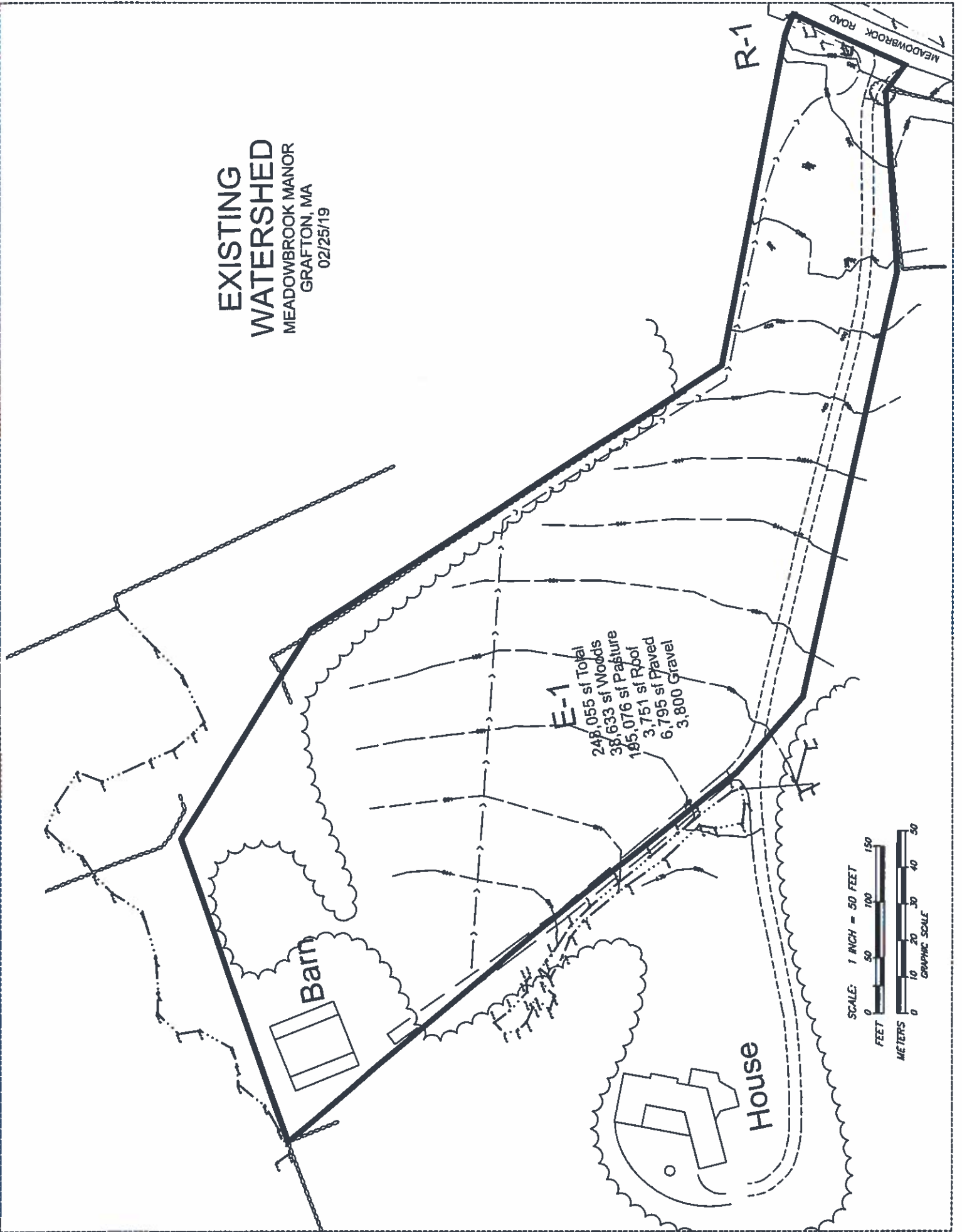
## CONCLUSION

Based upon the information and calculations presented in this Stormwater Plan, the proposed 2, 10, and 100-year peak discharge for the total watershed resulting from the development of the proposed site results in no increase in the 2, 10, and 100-year peak discharge from the total watershed existing condition.

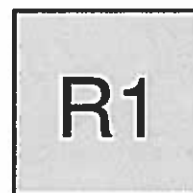
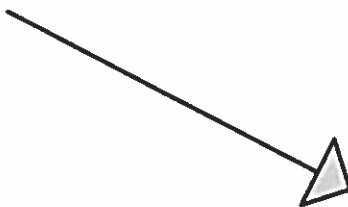
## APPENDIX 1

### EXISTING 2, 10, 100-YEAR TR-20 HYDROLOGIC CALCULATIONS

EXISTING  
WATERSHED  
MEADOWBROOK MANOR  
GRAFTON, MA  
02/25/19







EX Road Swale



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### Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.087	89	Gravel roads, HSG C (E1)
4.478	79	Pasture/grassland/range, Fair, HSG C (E1)
0.156	98	Paved parking, HSG C (E1)
0.086	98	Roofs, HSG C (E1)
0.887	73	Woods, Fair, HSG C (E1)
5.695	79	<b>TOTAL AREA</b>

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### Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
5.695	HSG C	E1
0.000	HSG D	
0.000	Other	
5.695		<b>TOTAL AREA</b>

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**Ground Covers (all nodes)**

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.087	0.000	0.000	0.087	Gravel roads	E1
0.000	0.000	4.478	0.000	0.000	4.478	Pasture/grassland/range, Fair	E1
0.000	0.000	0.156	0.000	0.000	0.156	Paved parking	E1
0.000	0.000	0.086	0.000	0.000	0.086	Roofs	E1
0.000	0.000	0.887	0.000	0.000	0.887	Woods, Fair	E1
<b>0.000</b>	<b>0.000</b>	<b>5.695</b>	<b>0.000</b>	<b>0.000</b>	<b>5.695</b>	<b>TOTAL AREA</b>	

## 18-102\_Meadowbrook\_EXIST

Type III 24-hr 2 year Grafton Rainfall=3.15"

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

### Subcatchment E1:

Runoff Area=248,055 sf 4.25% Impervious Runoff Depth>1.19"  
Flow Length=987' Tc=19.9 min CN=79 Runoff=5.72 cfs 0.565 af

### Reach R1: EX Road Swale

Inflow=5.72 cfs 0.565 af  
Outflow=5.72 cfs 0.565 af

Total Runoff Area = 5.695 ac Runoff Volume = 0.565 af Average Runoff Depth = 1.19"  
95.75% Pervious = 5.452 ac 4.25% Impervious = 0.242 ac

**Summary for Subcatchment E1:**

Runoff = 5.72 cfs @ 12.29 hrs, Volume= 0.565 af, Depth> 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2 year Grafton Rainfall=3.15"

Area (sf)	CN	Description
38,633	73	Woods, Fair, HSG C
195,076	79	Pasture/grassland/range, Fair, HSG C
3,751	98	Roofs, HSG C
6,795	98	Paved parking, HSG C
3,800	89	Gravel roads, HSG C
248,055	79	Weighted Average
237,509		95.75% Pervious Area
10,546		4.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	50	0.0320	0.20		<b>Sheet Flow, a-b</b> Range n= 0.130 P2= 3.10"
2.8	328	0.0780	1.95		<b>Shallow Concentrated Flow, b-c</b> Short Grass Pasture Kv= 7.0 fps
10.1	364	0.0575	0.60		<b>Shallow Concentrated Flow, c-d</b> Forest w/Heavy Litter Kv= 2.5 fps
2.2	164	0.0323	1.26		<b>Shallow Concentrated Flow, d-e</b> Short Grass Pasture Kv= 7.0 fps
0.6	81	0.1142	2.37		<b>Shallow Concentrated Flow, e-f</b> Short Grass Pasture Kv= 7.0 fps
19.9	987	Total			

# 18-102\_Meadowbrook\_EXIST

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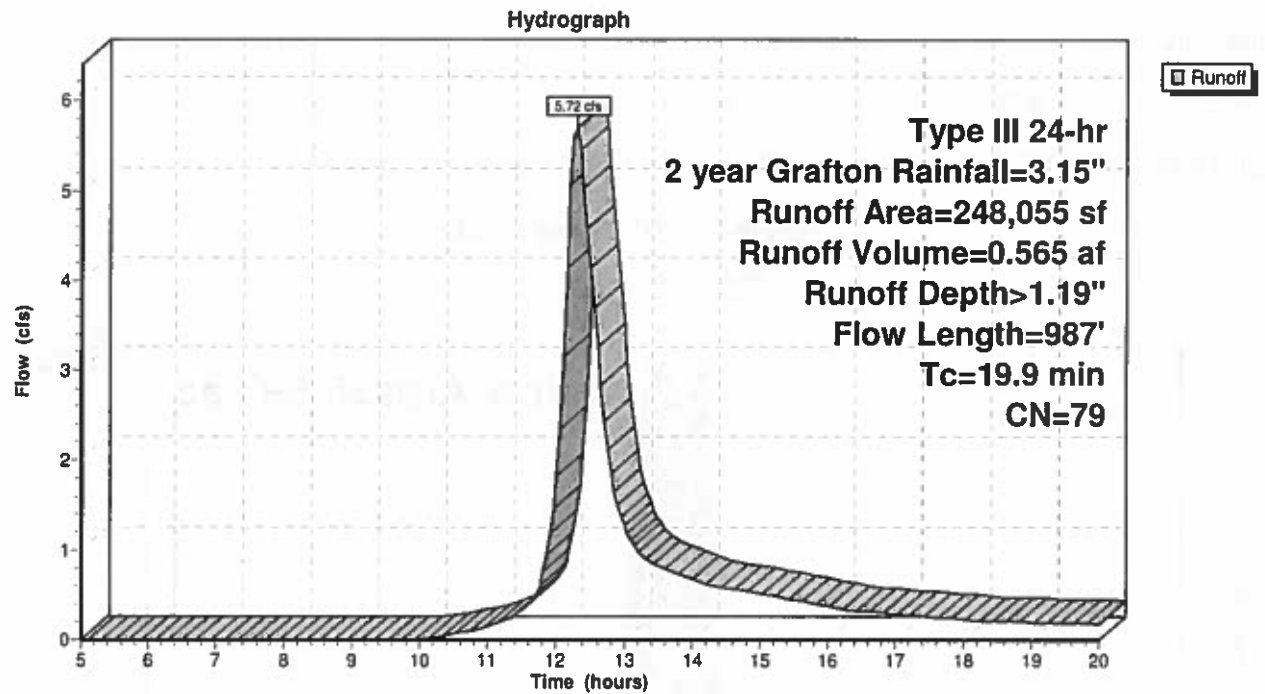
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Type III 24-hr 2 year Grafton Rainfall=3.15"

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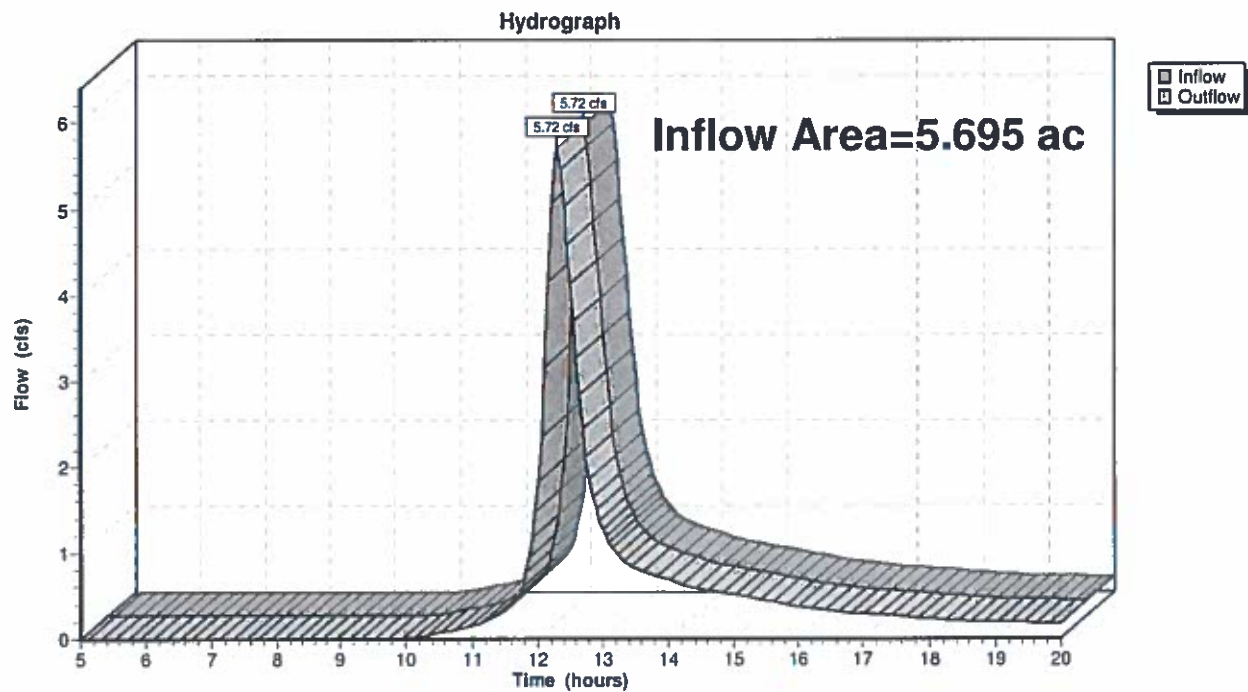
## Subcatchment E1:



**Summary for Reach R1: EX Road Swale**

Inflow Area = 5.695 ac, 4.25% Impervious, Inflow Depth > 1.19" for 2 year Grafton event  
Inflow = 5.72 cfs @ 12.29 hrs, Volume= 0.565 af  
Outflow = 5.72 cfs @ 12.29 hrs, Volume= 0.565 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

**Reach R1: EX Road Swale**



# 18-102\_Meadowbrook\_EXIST

Type III 24-hr 10 year Grafton Rainfall=4.70"

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

## Subcatchment E1:

Runoff Area=248,055 sf 4.25% Impervious Runoff Depth>2.36"  
Flow Length=987' Tc=19.9 min CN=79 Runoff=11.42 cfs 1.120 af

## Reach R1: EX Road Swale

Inflow=11.42 cfs 1.120 af  
Outflow=11.42 cfs 1.120 af

Total Runoff Area = 5.695 ac Runoff Volume = 1.120 af Average Runoff Depth = 2.36"  
95.75% Pervious = 5.452 ac 4.25% Impervious = 0.242 ac

**18-102\_Meadowbrook\_EXIST**

Type III 24-hr 10 year Grafton Rainfall=4.70"

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**Summary for Subcatchment E1:**

Runoff = 11.42 cfs @ 12.28 hrs, Volume= 1.120 af, Depth&gt; 2.36"

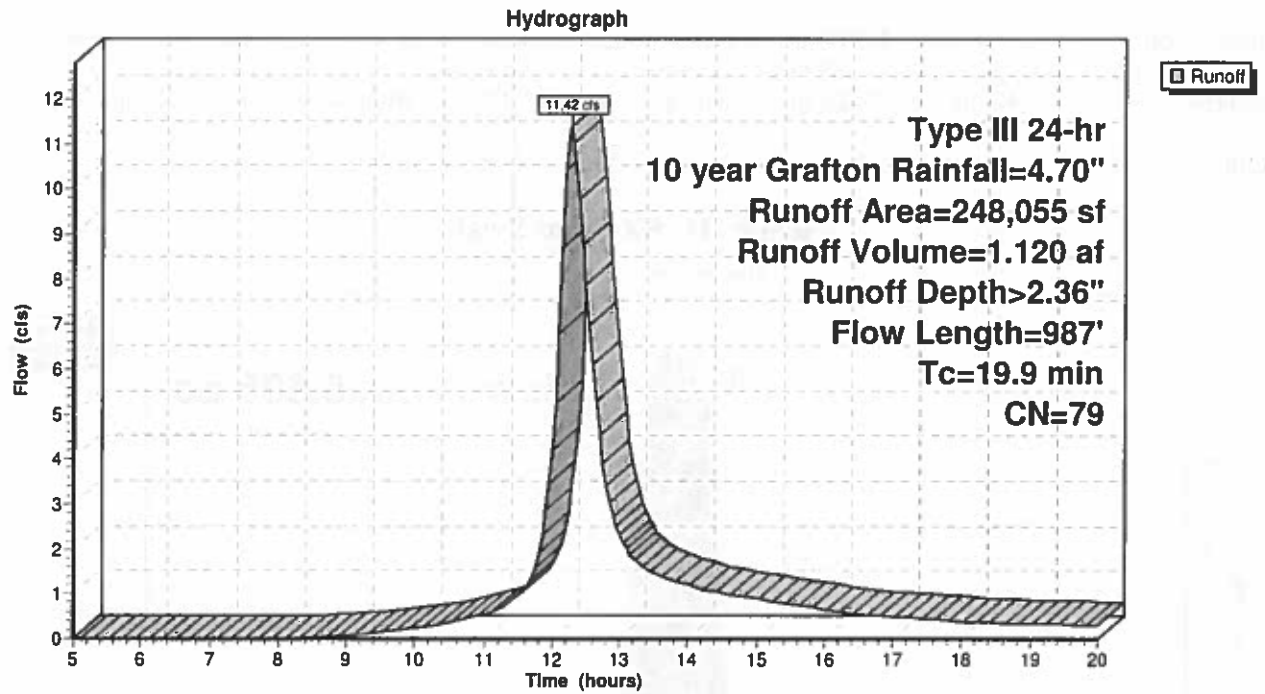
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10 year Grafton Rainfall=4.70"

Area (sf)	CN	Description
38,633	73	Woods, Fair, HSG C
195,076	79	Pasture/grassland/range, Fair, HSG C
3,751	98	Roofs, HSG C
6,795	98	Paved parking, HSG C
3,800	89	Gravel roads, HSG C
248,055	79	Weighted Average
237,509		95.75% Pervious Area
10,546		4.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	50	0.0320	0.20		<b>Sheet Flow, a-b</b> Range n= 0.130 P2= 3.10"
2.8	328	0.0780	1.95		<b>Shallow Concentrated Flow, b-c</b> Short Grass Pasture Kv= 7.0 fps
10.1	364	0.0575	0.60		<b>Shallow Concentrated Flow, c-d</b> Forest w/Heavy Litter Kv= 2.5 fps
2.2	164	0.0323	1.26		<b>Shallow Concentrated Flow, d-e</b> Short Grass Pasture Kv= 7.0 fps
0.6	81	0.1142	2.37		<b>Shallow Concentrated Flow, e-f</b> Short Grass Pasture Kv= 7.0 fps
19.9	987	Total			

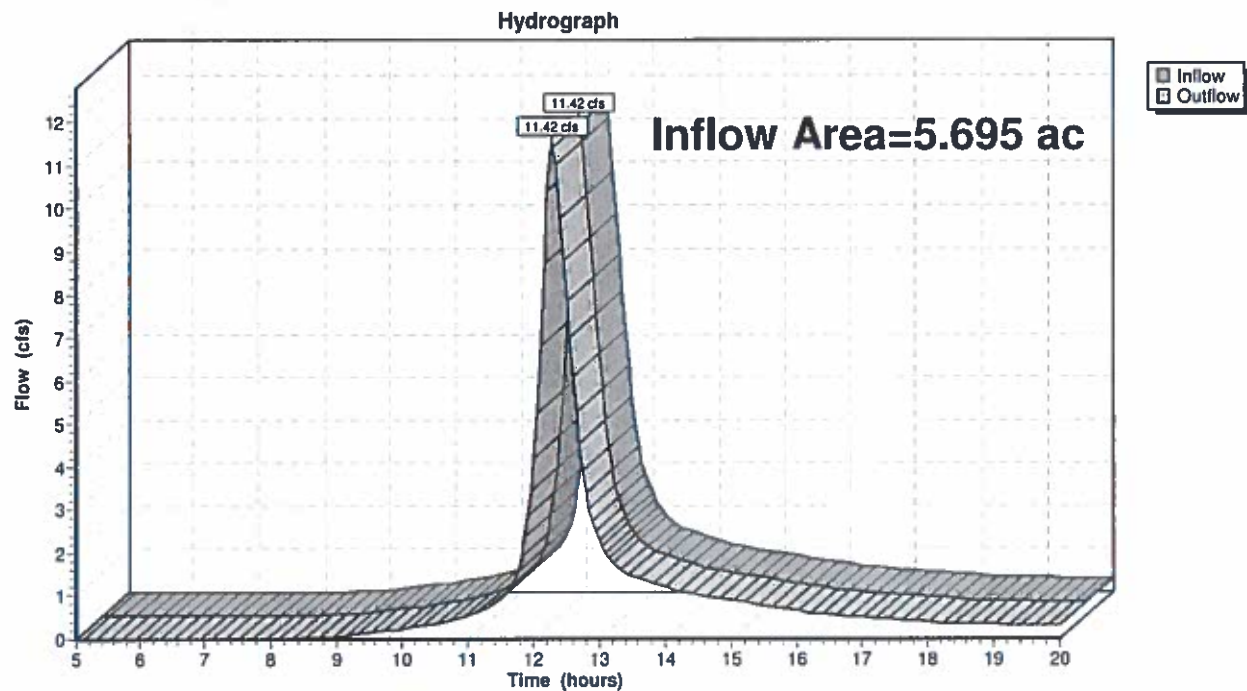
## Subcatchment E1:



**Summary for Reach R1: EX Road Swale**

Inflow Area = 5.695 ac, 4.25% Impervious, Inflow Depth > 2.36" for 10 year Grafton event  
Inflow = 11.42 cfs @ 12.28 hrs, Volume= 1.120 af  
Outflow = 11.42 cfs @ 12.28 hrs, Volume= 1.120 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

**Reach R1: EX Road Swale**

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Type III 24-hr 100 year Grafton Rainfall=8.35"

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

## Subcatchment E1:

Runoff Area=248,055 sf 4.25% Impervious Runoff Depth=5.47"  
Flow Length=987' Tc=19.9 min CN=79 Runoff=25.99 cfs 2.596 af

## Reach R1: EX Road Swale

Inflow=25.99 cfs 2.596 af  
Outflow=25.99 cfs 2.596 af

Total Runoff Area = 5.695 ac Runoff Volume = 2.596 af Average Runoff Depth = 5.47"  
95.75% Pervious = 5.452 ac 4.25% Impervious = 0.242 ac

**18-102\_Meadowbrook\_EXIST**

Type III 24-hr 100 year Grafton Rainfall=8.35"

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**Summary for Subcatchment E1:**

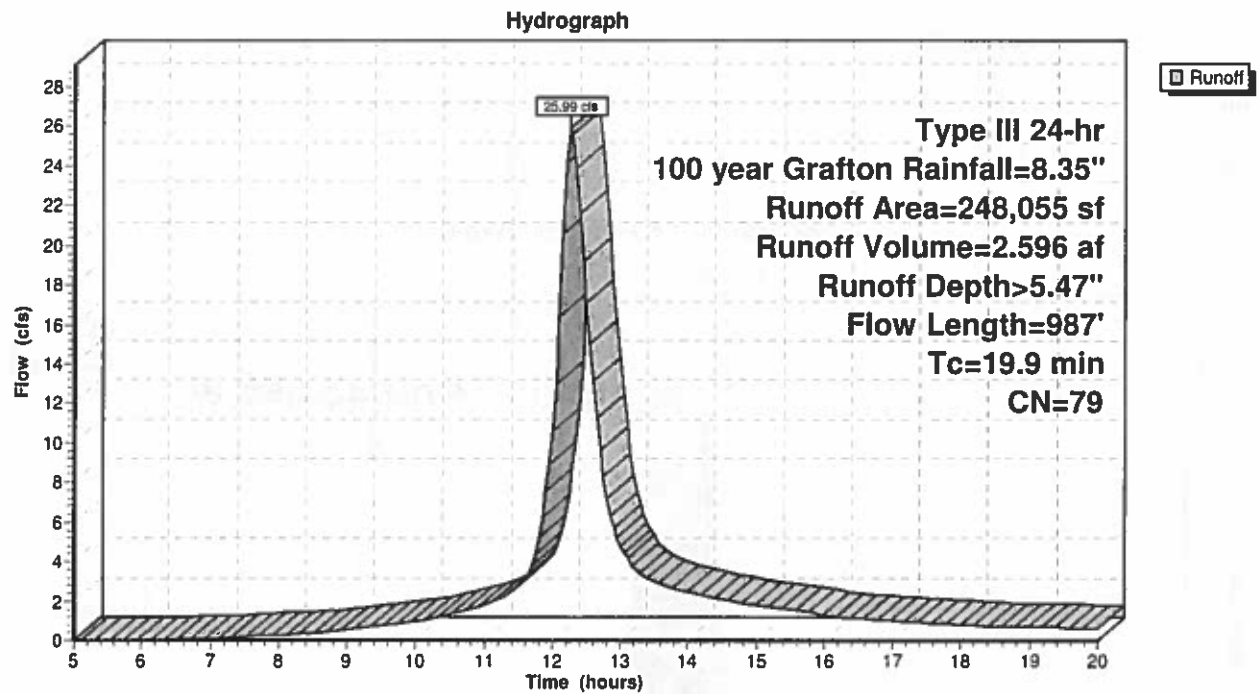
Runoff = 25.99 cfs @ 12.27 hrs, Volume= 2.596 af, Depth&gt; 5.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 year Grafton Rainfall=8.35"

Area (sf)	CN	Description
38,633	73	Woods, Fair, HSG C
195,076	79	Pasture/grassland/range, Fair, HSG C
3,751	98	Roofs, HSG C
6,795	98	Paved parking, HSG C
3,800	89	Gravel roads, HSG C
248,055	79	Weighted Average
237,509		95.75% Pervious Area
10,546		4.25% Impervious Area

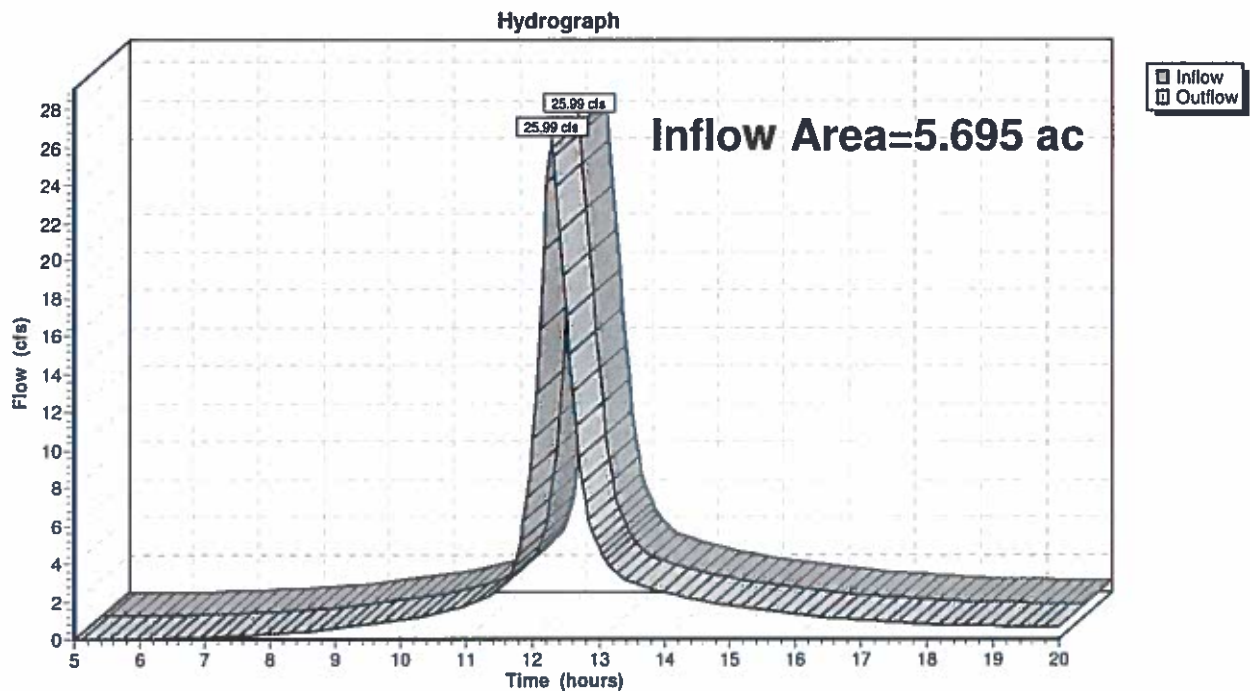
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	50	0.0320	0.20		<b>Sheet Flow, a-b</b> Range n= 0.130 P2= 3.10"
2.8	328	0.0780	1.95		<b>Shallow Concentrated Flow, b-c</b> Short Grass Pasture Kv= 7.0 fps
10.1	364	0.0575	0.60		<b>Shallow Concentrated Flow, c-d</b> Forest w/Heavy Litter Kv= 2.5 fps
2.2	164	0.0323	1.26		<b>Shallow Concentrated Flow, d-e</b> Short Grass Pasture Kv= 7.0 fps
0.6	81	0.1142	2.37		<b>Shallow Concentrated Flow, e-f</b> Short Grass Pasture Kv= 7.0 fps
19.9	987	Total			

**Subcatchment E1:**

**Summary for Reach R1: EX Road Swale**

Inflow Area = 5.695 ac, 4.25% Impervious, Inflow Depth > 5.47" for 100 year Grafton event  
Inflow = 25.99 cfs @ 12.27 hrs, Volume= 2.596 af  
Outflow = 25.99 cfs @ 12.27 hrs, Volume= 2.596 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

**Reach R1: EX Road Swale**



## APPENDIX 2

### PROPOSED 2, 10, 100-YEAR TR-20 HYDROLOGIC CALCULATIONS

**PROPOSED  
WATERSHED**  
MEADOWBROOK MANOR  
GRAFTON, MA  
02/25/19

**P-2**  
96,650 sf Total  
45,927 sf Pasture  
25,000 lawn  
1,800 sf roof  
23,932 sf Woods

**Barn**

**P-1**  
181,932 sf Total  
77,576 sf Pasture  
14,710 sf Woods  
4,560 sf ExPave  
6,735 sf NewPave  
3,800 sf ExGravel  
5,551 sf Roof  
25,000 Lawn

**LOT 2**  
44,587 ± sf

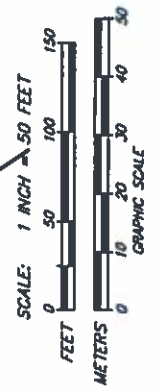
**P-3**  
19,473 sf Total  
14,993 sf Pasture  
2,235 sf ExPave  
2,245 sf NewPave

**LOT 1**  
64,356 ± sf

**LOT 3**  
(REMAINING)  
9.32 ± AC

**House**

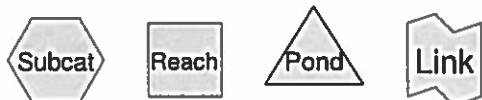
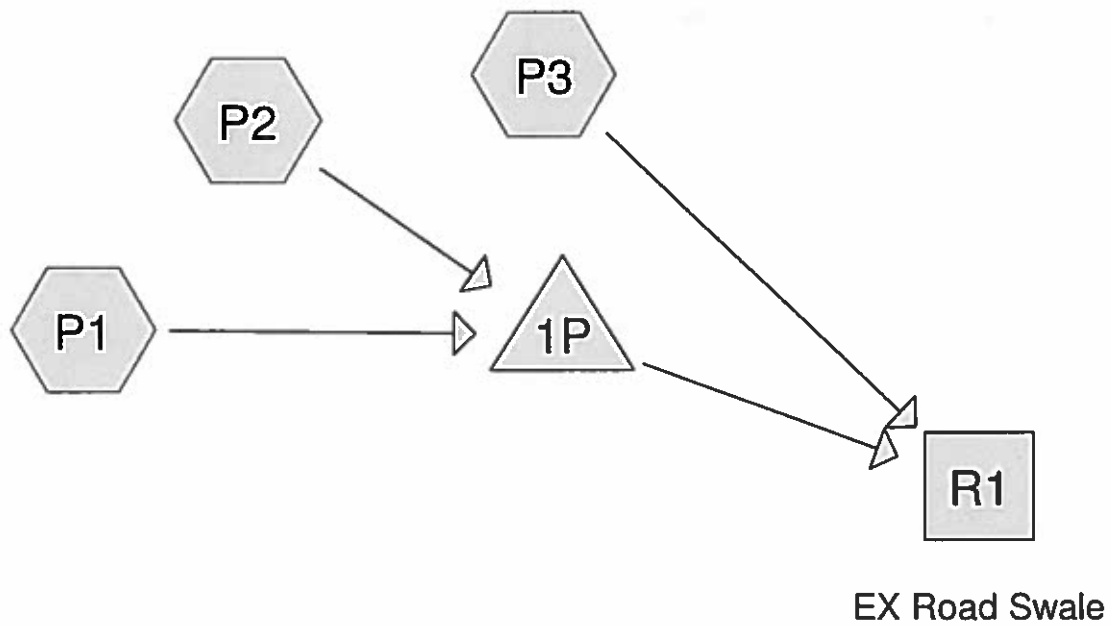
**R-1**



40' ROADWAY 25-686 ± ft

MEADOWBROOK ROAD

WOODBIDGE FINE SANDY LOAM  
PASTON FINE SANDY LOAM



Routing Diagram for 18-102\_Meadowbrook\_PROP Revised 5.8.19  
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**Area Listing (all nodes)**

Area (acres)	CN	Description (subcatchment-numbers)
1.148	74	>75% Grass cover, Good, HSG C (P1, P2)
0.087	89	Gravel roads, HSG C (P1)
3.042	79	Pasture/grassland/range, Fair, HSG C (P1, P2, P3)
0.362	98	Paved parking, HSG C (P1, P3)
0.169	98	Roofs, HSG C (P1, P2)
0.887	73	Woods, Fair, HSG C (P1, P2)
5.695	79	<b>TOTAL AREA</b>

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**Soil Listing (all nodes)**

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
5.695	HSG C	P1, P2, P3
0.000	HSG D	
0.000	Other	
5.695		<b>TOTAL AREA</b>

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**Ground Covers (all nodes)**

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	1.148	0.000	0.000	1.148	>75% Grass cover, Good	P1, P2
0.000	0.000	0.087	0.000	0.000	0.087	Gravel roads	P1
0.000	0.000	3.042	0.000	0.000	3.042	Pasture/grassland/range, Fair	P1, P2, P3
0.000	0.000	0.362	0.000	0.000	0.362	Paved parking	P1, P3
0.000	0.000	0.169	0.000	0.000	0.169	Roofs	P1, P2
0.000	0.000	0.887	0.000	0.000	0.887	Woods, Fair	P1, P2
0.000	0.000	5.695	0.000	0.000	5.695	<b>TOTAL AREA</b>	

**18-102\_Meadowbrook\_PROP Revised 5.8.19**

Prepared by S. Bressette

Printed 5/13/19

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Page 5

**Pipe Listing (all nodes)**

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	1P	390.50	390.00	50.0	0.0100	0.010	18.0	0.0	0.0

Time span=5.00-80.00 hrs, dt=0.03 hrs, 2501 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment P1:**

Runoff Area=131,932 sf 12.77% Impervious Runoff Depth=1.36"  
Flow Length=755' Tc=11.9 min CN=80 Runoff=3.92 cfs 0.344 af

**Subcatchment P2:**

Runoff Area=96,650 sf 1.86% Impervious Runoff Depth=1.18"  
Flow Length=605' Tc=9.0 min CN=77 Runoff=2.66 cfs 0.217 af

**Subcatchment P3:**

Runoff Area=19,473 sf 23.01% Impervious Runoff Depth=1.57"  
Tc=6.0 min CN=83 Runoff=0.82 cfs 0.058 af

**Reach R1: EX Road Swale**

Inflow=2.71 cfs 0.593 af  
Outflow=2.71 cfs 0.593 af

**Pond 1P:**

Peak Elev=394.17' Storage=7,311 cf Inflow=6.50 cfs 0.562 af  
Discarded=0.02 cfs 0.027 af Primary=2.52 cfs 0.535 af Secondary=0.00 cfs 0.000 af Outflow=2.54 cfs 0.562 af

**Total Runoff Area = 5.695 ac Runoff Volume = 0.620 af Average Runoff Depth = 1.31"**  
**90.68% Pervious = 5.164 ac 9.32% Impervious = 0.531 ac**



**Summary for Subcatchment P1:**

Runoff = 3.92 cfs @ 12.17 hrs, Volume= 0.344 af, Depth= 1.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
Type III 24-hr 2 year Grafton Rainfall=3.15"

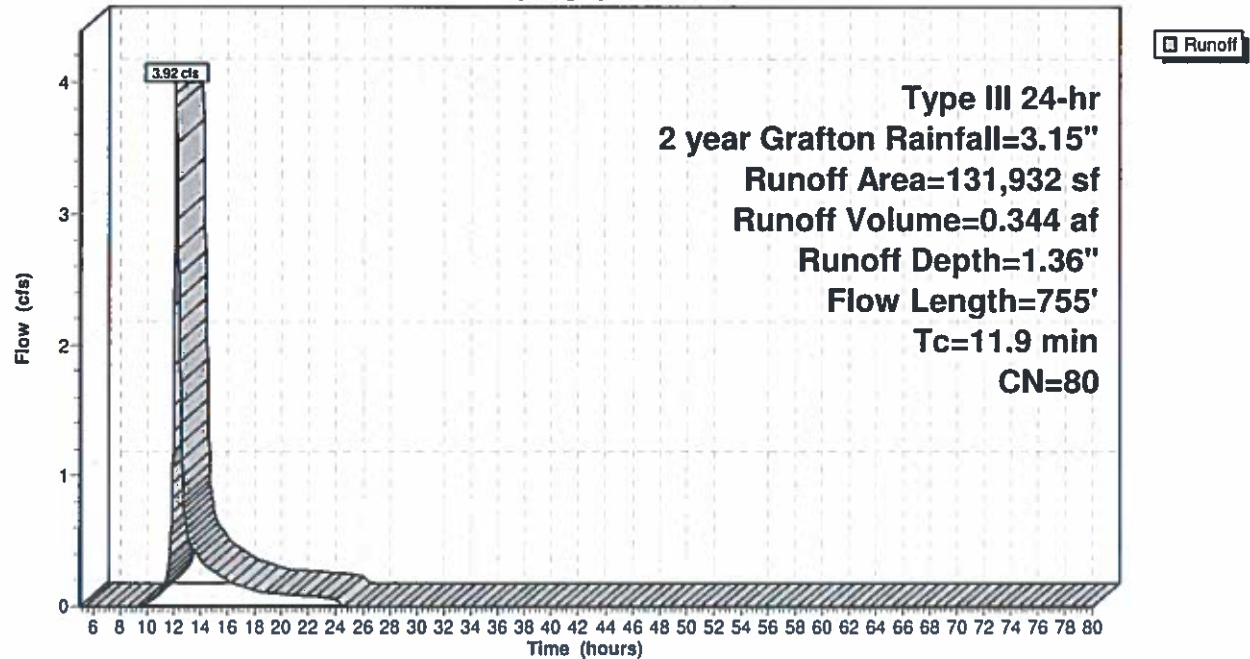
Area (sf)	CN	Description
14,710	73	Woods, Fair, HSG C
71,576	79	Pasture/grassland/range, Fair, HSG C
5,551	98	Roofs, HSG C
11,295	98	Paved parking, HSG C
3,800	89	Gravel roads, HSG C
25,000	74	>75% Grass cover, Good, HSG C
131,932	80	Weighted Average
115,086		87.23% Pervious Area
16,846		12.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	75	0.0340	0.22		<b>Sheet Flow, a-75'</b> Range n= 0.130 P2= 3.10"
2.1	225	0.0632	1.76		<b>Shallow Concentrated Flow, 75'-b</b> Short Grass Pasture Kv= 7.0 fps
3.4	375	0.0693	1.84		<b>Shallow Concentrated Flow, b-c</b> Short Grass Pasture Kv= 7.0 fps
0.7	80	0.0750	1.92		<b>Shallow Concentrated Flow, c-d</b> Short Grass Pasture Kv= 7.0 fps
11.9	755	Total			

**Subcatchment P1:**

Hydrograph



**Summary for Subcatchment P2:**

Runoff = 2.66 cfs @ 12.14 hrs, Volume= 0.217 af, Depth= 1.18"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
Type III 24-hr 2 year Grafton Rainfall=3.15"

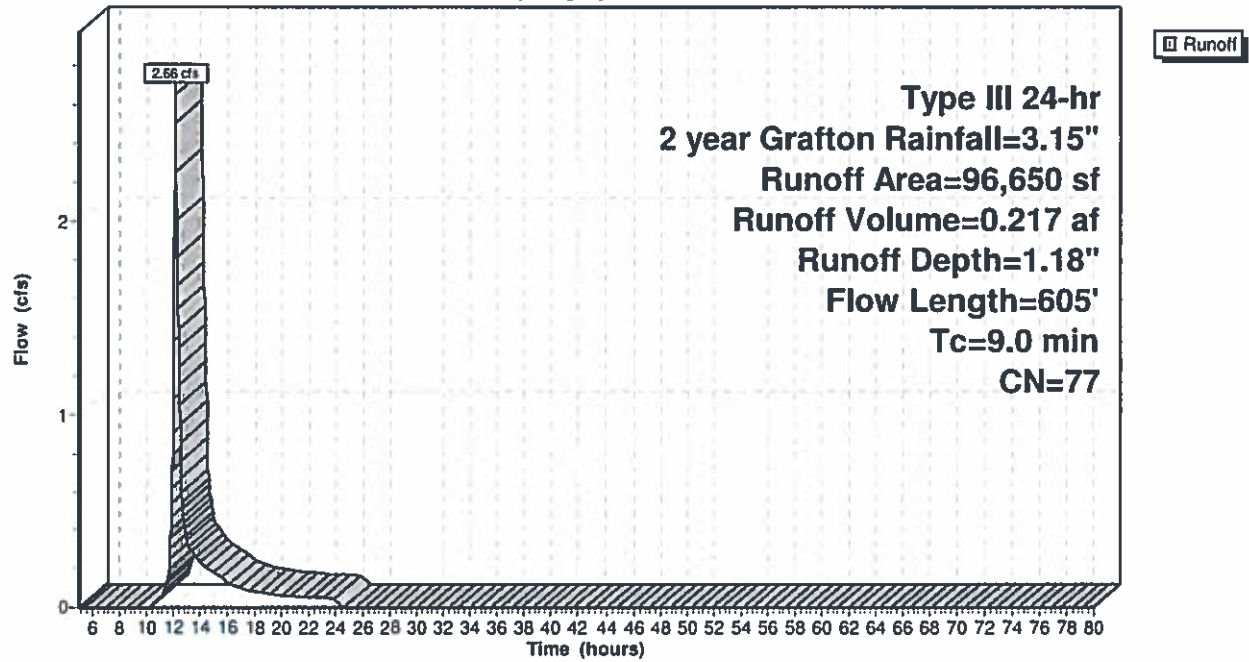
Area (sf)	CN	Description
23,923	73	Woods, Fair, HSG C
45,927	79	Pasture/grassland/range, Fair, HSG C
25,000	74	>75% Grass cover, Good, HSG C
1,800	98	Roofs, HSG C
96,650	77	Weighted Average
94,850		98.14% Pervious Area
1,800		1.86% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.0	75	0.0840	0.31		<b>Sheet Flow, a-75'</b>
					Range n= 0.130 P2= 3.10"
1.4	170	0.0810	1.99		<b>Shallow Concentrated Flow, 75'-b</b>
					Short Grass Pasture Kv= 7.0 fps
2.4	230	0.0500	1.57		<b>Shallow Concentrated Flow, b-c</b>
					Short Grass Pasture Kv= 7.0 fps
1.2	130	0.0650	1.78		<b>Shallow Concentrated Flow, c-d</b>
					Short Grass Pasture Kv= 7.0 fps
9.0	605	Total			

**Subcatchment P2:**

Hydrograph



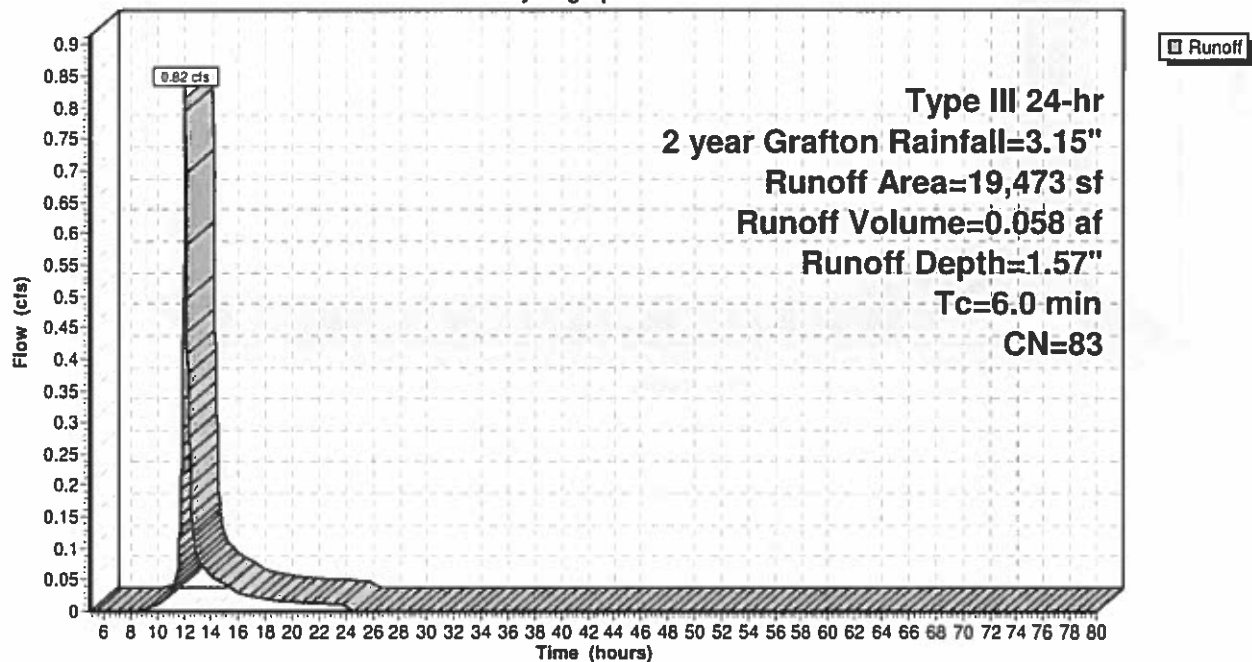
**Summary for Subcatchment P3:**

Runoff = 0.82 cfs @ 12.09 hrs, Volume= 0.058 af, Depth= 1.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
Type III 24-hr 2 year Grafton Rainfall=3.15"

Area (sf)	CN	Description
14,993	79	Pasture/grassland/range, Fair, HSG C
4,480	98	Paved parking, HSG C
19,473	83	Weighted Average
14,993		76.99% Pervious Area
4,480		23.01% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry,

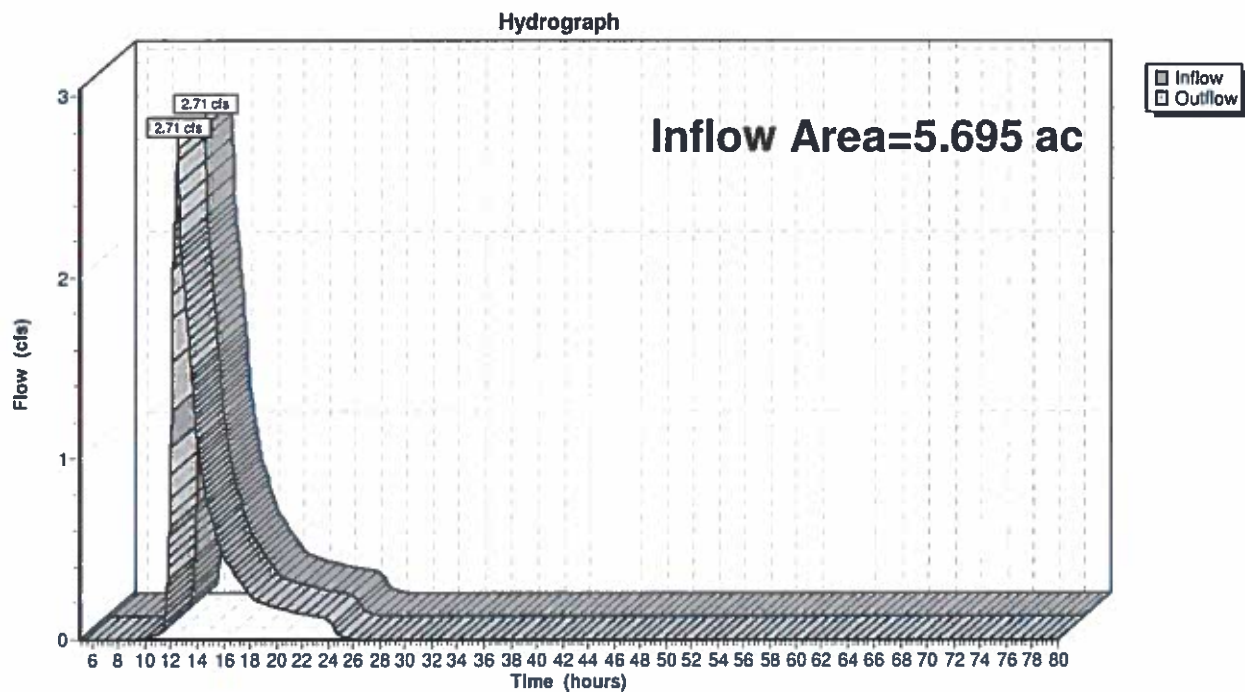
**Subcatchment P3:****Hydrograph**

**Summary for Reach R1: EX Road Swale**

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.695 ac, 9.32% Impervious, Inflow Depth = 1.25" for 2 year Grafton event  
Inflow = 2.71 cfs @ 12.50 hrs, Volume= 0.593 af  
Outflow = 2.71 cfs @ 12.50 hrs, Volume= 0.593 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs

**Reach R1: EX Road Swale**

**Summary for Pond 1P:**

Inflow Area = 5.248 ac, 8.16% Impervious, Inflow Depth = 1.28" for 2 year Grafton event  
 Inflow = 6.50 cfs @ 12.15 hrs, Volume= 0.562 af  
 Outflow = 2.54 cfs @ 12.52 hrs, Volume= 0.562 af, Atten= 61%, Lag= 21.7 min  
 Discarded = 0.02 cfs @ 12.52 hrs, Volume= 0.027 af  
 Primary = 2.52 cfs @ 12.52 hrs, Volume= 0.535 af  
 Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs / 3  
 Peak Elev= 394.17' @ 12.52 hrs Surf.Area= 4,635 sf Storage= 7,311 cf

Plug-Flow detention time= 77.0 min calculated for 0.561 af (100% of inflow)  
 Center-of-Mass det. time= 77.8 min ( 929.5 - 851.8 )

Volume	Invert	Avail.Storage	Storage Description
#1	392.00'	20,313 cf	<b>Custom Stage Data (Prismatic) Listed below (Recalc)</b>
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
392.00	1,105	0	0
393.00	3,725	2,415	2,415
394.00	4,505	4,115	6,530
395.00	5,263	4,884	11,414
396.00	6,153	5,708	17,122
396.50	6,609	3,191	20,313

Device	Routing	Invert	Outlet Devices
#1	Discarded	392.00'	<b>0.170 in/hr Exfiltration over Horizontal area</b> Conductivity to Groundwater Elevation = -2.50'
#2	Device 6	393.00'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#3	Device 6	392.50'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#4	Device 6	392.75'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#5	Device 6	394.10'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#6	Primary	390.50'	<b>18.0" Round Culvert</b> L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 390.50' / 390.00' S= 0.0100 ' Cc= 0.900 n= 0.010, Flow Area= 1.77 sf
#7	Device 6	393.25'	<b>2.0" Vert. Orifice/Grate X 4.00</b> C= 0.600
#8	Device 6	392.35'	<b>1.5" Vert. Orifice/Grate X 8.00</b> C= 0.600
#9	Secondary	395.75'	<b>6.0' long x 8.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.43 2.54 2.70 2.69 2.68 2.68 2.66 2.64 2.64 2.64 2.65 2.65 2.66 2.66 2.68 2.70 2.74

**Discarded OutFlow** Max=0.02 cfs @ 12.52 hrs HW=394.17' (Free Discharge)

↑1=Exfiltration ( Controls 0.02 cfs)

**Primary OutFlow** Max=2.50 cfs @ 12.52 hrs HW=394.17' (Free Discharge)

↑6=Culvert (Passes 2.50 cfs of 14.54 cfs potential flow)

↑2=Orifice/Grate (Orifice Controls 0.33 cfs @ 5.12 fps)

↑3=Orifice/Grate (Orifice Controls 0.40 cfs @ 6.14 fps)

↑4=Orifice/Grate (Orifice Controls 0.37 cfs @ 5.65 fps)

↑5=Orifice/Grate (Weir Controls 0.38 cfs @ 0.87 fps)

↑7=Orifice/Grate (Orifice Controls 0.38 cfs @ 4.40 fps)

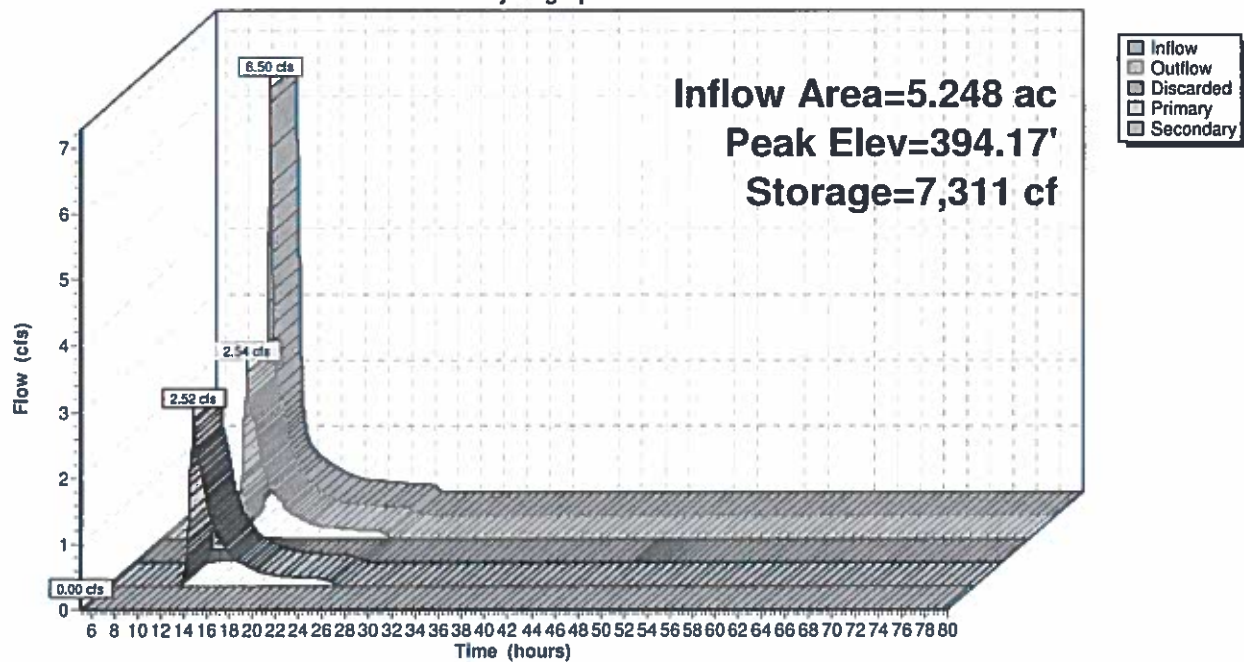
↑8=Orifice/Grate (Orifice Controls 0.63 cfs @ 6.38 fps)

**Secondary OutFlow** Max=0.00 cfs @ 5.00 hrs HW=392.00' (Free Discharge)

↑9=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

### Pond 1P:

Hydrograph





Time span=5.00-80.00 hrs, dt=0.03 hrs, 2501 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment P1:** Runoff Area=131,932 sf 12.77% Impervious Runoff Depth=2.63"  
Flow Length=755' Tc=11.9 min CN=80 Runoff=7.68 cfs 0.665 af

**Subcatchment P2:** Runoff Area=96,650 sf 1.86% Impervious Runoff Depth=2.37"  
Flow Length=605' Tc=9.0 min CN=77 Runoff=5.53 cfs 0.439 af

**Subcatchment P3:** Runoff Area=19,473 sf 23.01% Impervious Runoff Depth=2.90"  
Tc=6.0 min CN=83 Runoff=1.51 cfs 0.108 af

**Reach R1: EX Road Swale** Inflow=11.41 cfs 1.181 af  
Outflow=11.41 cfs 1.181 af

**Pond 1P:** Peak Elev=394.64' Storage=9,571 cf Inflow=13.06 cfs 1.103 af  
Discarded=0.02 cfs 0.030 af Primary=10.64 cfs 1.073 af Secondary=0.00 cfs 0.000 af Outflow=10.66 cfs 1.104 af

**Total Runoff Area = 5.695 ac Runoff Volume = 1.212 af Average Runoff Depth = 2.55"**  
**90.68% Pervious = 5.164 ac 9.32% Impervious = 0.531 ac**

**Summary for Subcatchment P1:**

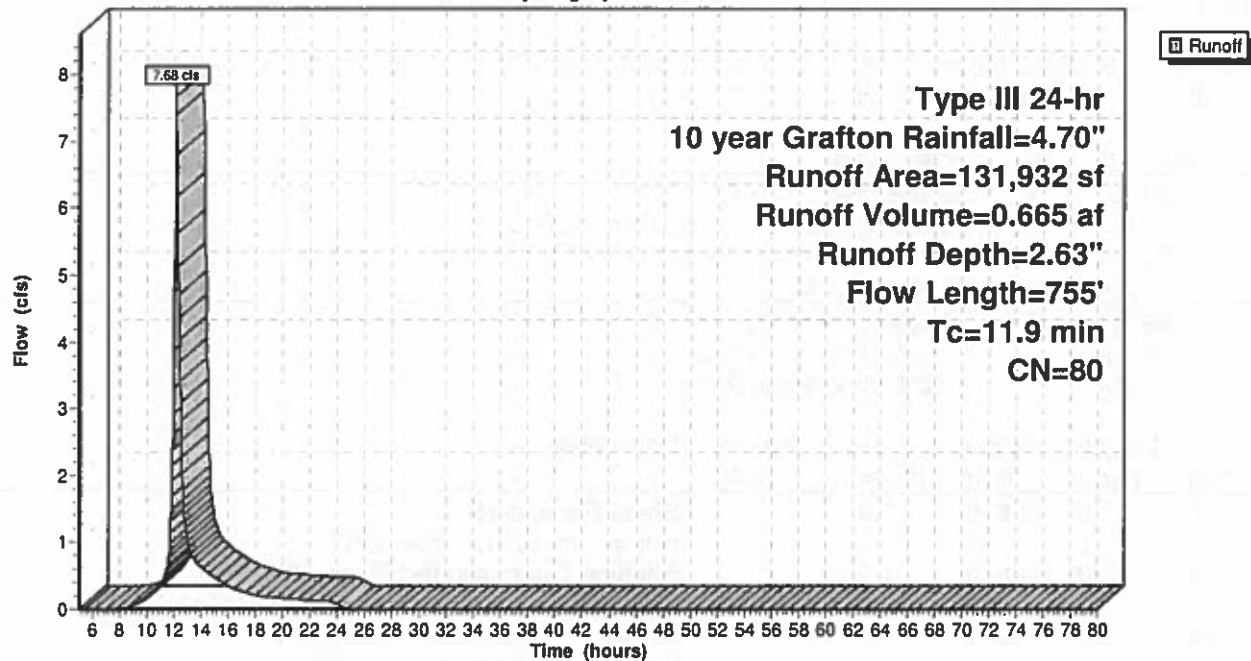
Runoff = 7.68 cfs @ 12.17 hrs, Volume= 0.665 af, Depth= 2.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
Type III 24-hr 10 year Grafton Rainfall=4.70"

Area (sf)	CN	Description
14,710	73	Woods, Fair, HSG C
71,576	79	Pasture/grassland/range, Fair, HSG C
5,551	98	Roofs, HSG C
11,295	98	Paved parking, HSG C
3,800	89	Gravel roads, HSG C
25,000	74	>75% Grass cover, Good, HSG C
131,932	80	Weighted Average
115,086		87.23% Pervious Area
16,846		12.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	75	0.0340	0.22		<b>Sheet Flow, a-75'</b> Range n= 0.130 P2= 3.10"
2.1	225	0.0632	1.76		<b>Shallow Concentrated Flow, 75'-b</b> Short Grass Pasture Kv= 7.0 fps
3.4	375	0.0693	1.84		<b>Shallow Concentrated Flow, b-c</b> Short Grass Pasture Kv= 7.0 fps
0.7	80	0.0750	1.92		<b>Shallow Concentrated Flow, c-d</b> Short Grass Pasture Kv= 7.0 fps
11.9	755	Total			

**Subcatchment P1:****Hydrograph**

**Summary for Subcatchment P2:**

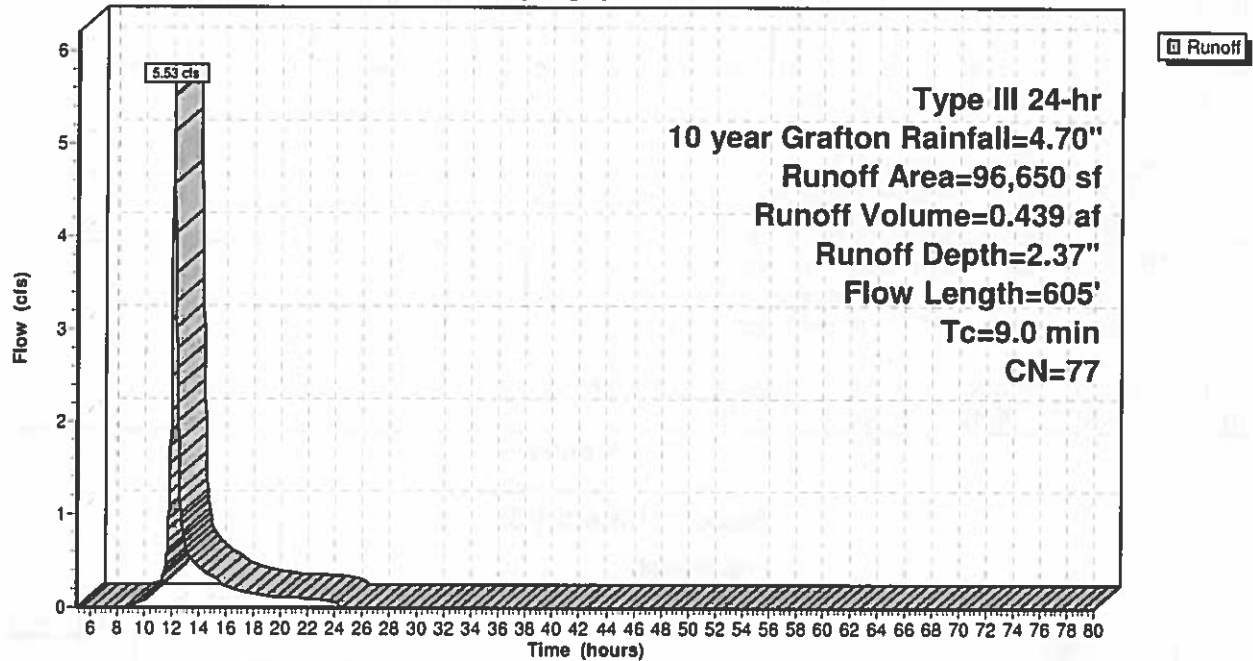
Runoff = 5.53 cfs @ 12.13 hrs, Volume= 0.439 af, Depth= 2.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
Type III 24-hr 10 year Grafton Rainfall=4.70"

Area (sf)	CN	Description
23,923	73	Woods, Fair, HSG C
45,927	79	Pasture/grassland/range, Fair, HSG C
25,000	74	>75% Grass cover, Good, HSG C
1,800	98	Roofs, HSG C
96,650	77	Weighted Average
94,850		98.14% Pervious Area
1,800		1.86% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.0	75	0.0840	0.31		<b>Sheet Flow, a-75'</b> Range n= 0.130 P2= 3.10"
1.4	170	0.0810	1.99		<b>Shallow Concentrated Flow, 75'-b</b> Short Grass Pasture Kv= 7.0 fps
2.4	230	0.0500	1.57		<b>Shallow Concentrated Flow, b-c</b> Short Grass Pasture Kv= 7.0 fps
1.2	130	0.0650	1.78		<b>Shallow Concentrated Flow, c-d</b> Short Grass Pasture Kv= 7.0 fps
9.0	605	Total			

**Subcatchment P2:****Hydrograph**

**Summary for Subcatchment P3:**

Runoff = 1.51 cfs @ 12.09 hrs, Volume= 0.108 af, Depth= 2.90"

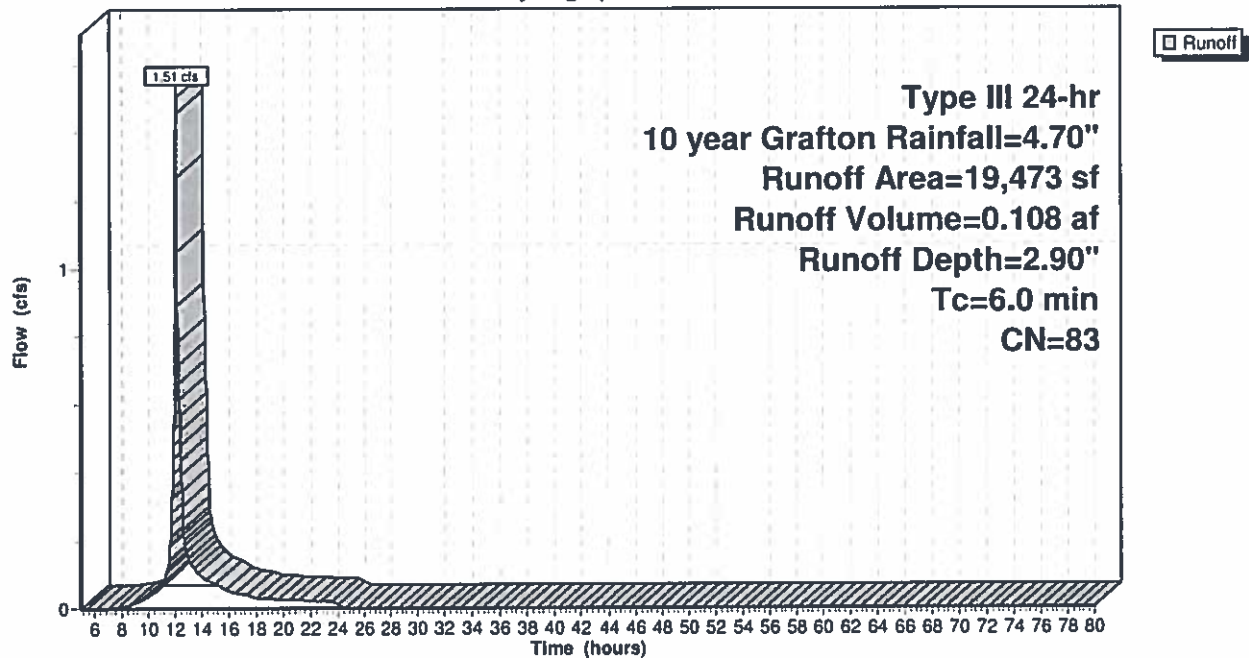
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
Type III 24-hr 10 year Grafton Rainfall=4.70"

Area (sf)	CN	Description
14,993	79	Pasture/grassland/range, Fair, HSG C
4,480	98	Paved parking, HSG C
19,473	83	Weighted Average
14,993		76.99% Pervious Area
4,480		23.01% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry,

**Subcatchment P3:**

Hydrograph



**Summary for Reach R1: EX Road Swale**

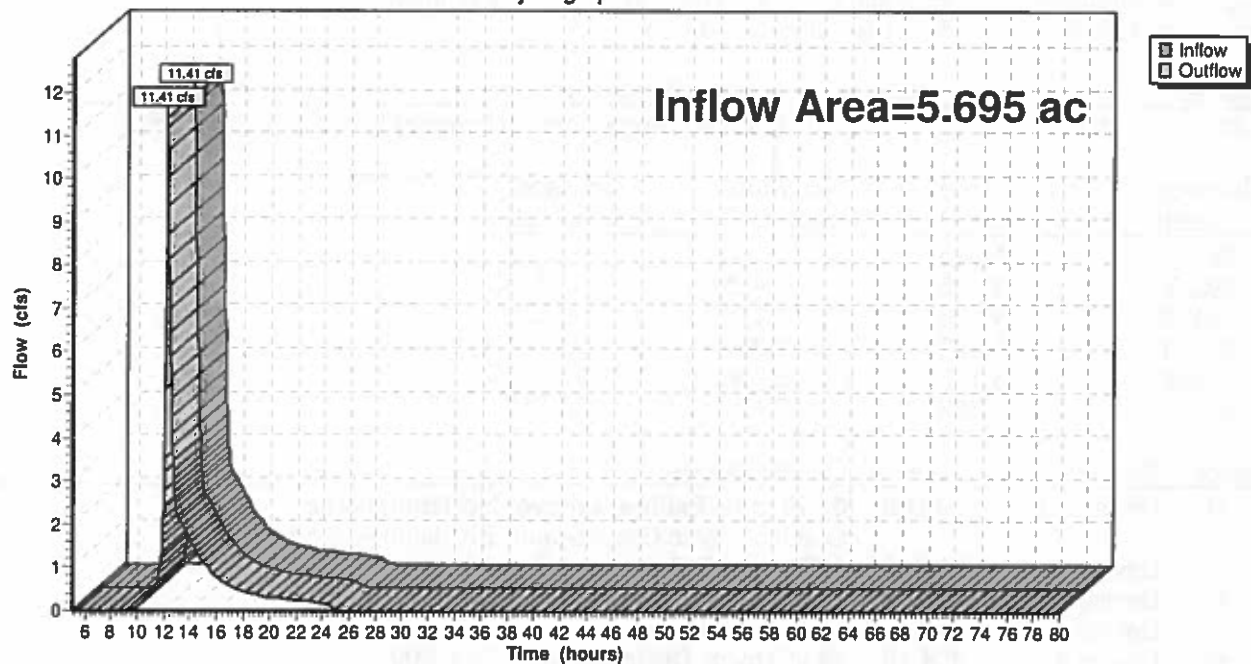
[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.695 ac, 9.32% Impervious, Inflow Depth = 2.49" for 10 year Grafton event  
Inflow = 11.41 cfs @ 12.23 hrs, Volume= 1.181 af  
Outflow = 11.41 cfs @ 12.23 hrs, Volume= 1.181 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs

**Reach R1: EX Road Swale**

Hydrograph



**Summary for Pond 1P:**

Inflow Area = 5.248 ac, 8.16% Impervious, Inflow Depth = 2.52" for 10 year Grafton event  
 Inflow = 13.06 cfs @ 12.15 hrs, Volume= 1.103 af  
 Outflow = 10.66 cfs @ 12.24 hrs, Volume= 1.104 af, Atten= 18%, Lag= 5.4 min  
 Discarded = 0.02 cfs @ 12.24 hrs, Volume= 0.030 af  
 Primary = 10.64 cfs @ 12.24 hrs, Volume= 1.073 af  
 Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs / 3  
 Peak Elev= 394.64' @ 12.24 hrs Surf.Area= 4,990 sf Storage= 9,571 cf

Plug-Flow detention time= 53.2 min calculated for 1.103 af (100% of inflow)  
 Center-of-Mass det. time= 53.9 min ( 886.1 - 832.1 )

Volume	Invert	Avail.Storage	Storage Description
#1	392.00'	20,313 cf	<b>Custom Stage Data (Prismatic) Listed below (Recalc)</b>

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
392.00	1,105	0	0
393.00	3,725	2,415	2,415
394.00	4,505	4,115	6,530
395.00	5,263	4,884	11,414
396.00	6,153	5,708	17,122
396.50	6,609	3,191	20,313

Device	Routing	Invert	Outlet Devices
#1	Discarded	392.00'	<b>0.170 in/hr Exfiltration over Horizontal area</b> Conductivity to Groundwater Elevation = -2.50'
#2	Device 6	393.00'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#3	Device 6	392.50'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#4	Device 6	392.75'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#5	Device 6	394.10'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#6	Primary	390.50'	<b>18.0" Round Culvert</b> L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 390.50' / 390.00' S= 0.0100 '/' Cc= 0.900 n= 0.010, Flow Area= 1.77 sf
#7	Device 6	393.25'	<b>2.0" Vert. Orifice/Grate X 4.00</b> C= 0.600
#8	Device 6	392.35'	<b>1.5" Vert. Orifice/Grate X 8.00</b> C= 0.600
#9	Secondary	395.75'	<b>6.0' long x 8.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.43 2.54 2.70 2.69 2.68 2.68 2.66 2.64 2.64 2.64 2.65 2.65 2.66 2.66 2.68 2.70 2.74



**Discarded OutFlow** Max=0.02 cfs @ 12.24 hrs HW=394.64' (Free Discharge)

1=Exfiltration ( Controls 0.02 cfs)

**Primary OutFlow** Max=10.57 cfs @ 12.24 hrs HW=394.64' (Free Discharge)

6=Culvert (Passes 10.57 cfs of 15.66 cfs potential flow)

2=Orifice/Grate (Orifice Controls 0.40 cfs @ 6.08 fps)

3=Orifice/Grate (Orifice Controls 0.46 cfs @ 6.97 fps)

4=Orifice/Grate (Orifice Controls 0.43 cfs @ 6.54 fps)

5=Orifice/Grate (Weir Controls 8.10 cfs @ 2.40 fps)

7=Orifice/Grate (Orifice Controls 0.48 cfs @ 5.50 fps)

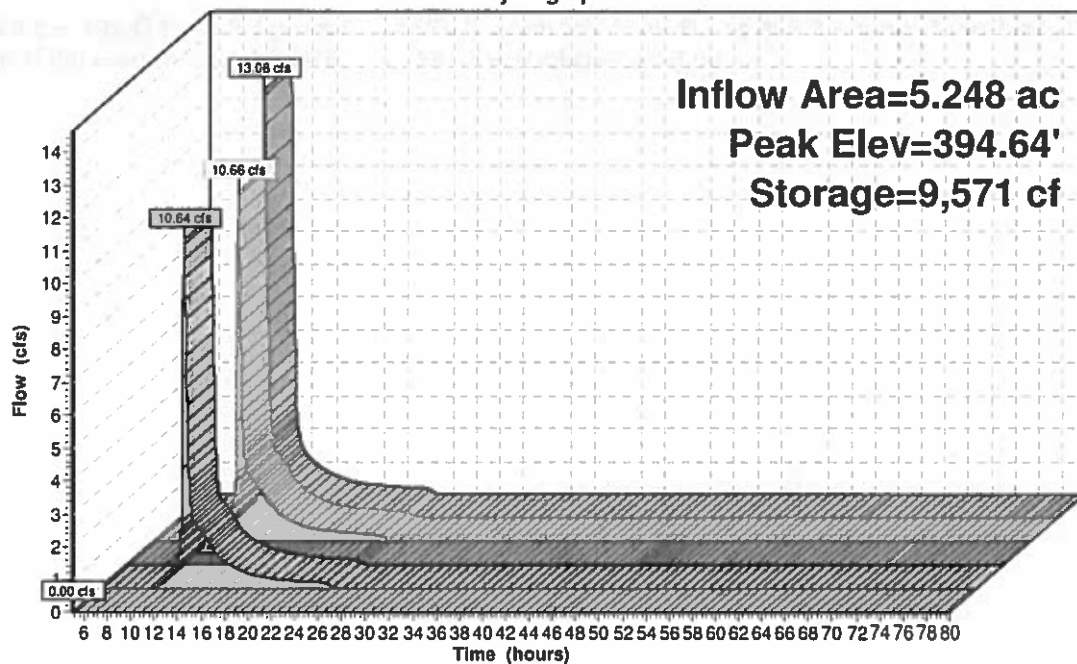
8=Orifice/Grate (Orifice Controls 0.71 cfs @ 7.18 fps)

**Secondary OutFlow** Max=0.00 cfs @ 5.00 hrs HW=392.00' (Free Discharge)

9=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

### Pond 1P:

Hydrograph



Time span=5.00-80.00 hrs, dt=0.03 hrs, 2501 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment P1:**    Runoff Area=131,932 sf    12.77% Impervious    Runoff Depth=5.95"  
Flow Length=755'    Tc=11.9 min    CN=80    Runoff=17.11 cfs    1.503 af

**Subcatchment P2:**    Runoff Area=96,650 sf    1.86% Impervious    Runoff Depth=5.60"  
Flow Length=605'    Tc=9.0 min    CN=77    Runoff=12.96 cfs    1.035 af

**Subcatchment P3:**    Runoff Area=19,473 sf    23.01% Impervious    Runoff Depth>6.31"  
Tc=6.0 min    CN=83    Runoff=3.20 cfs    0.235 af

**Reach R1: EX Road Swale**    Inflow=21.59 cfs    2.737 af  
Outflow=21.59 cfs    2.737 af

**Pond 1P:**    Peak Elev=395.98'    Storage=17,021 cf    Inflow=29.70 cfs    2.537 af  
Discarded=0.02 cfs    0.036 af    Primary=18.51 cfs    2.483 af    Secondary=1.66 cfs    0.018 af    Outflow=20.20 cfs    2.537 af

**Total Runoff Area = 5.695 ac    Runoff Volume = 2.773 af    Average Runoff Depth = 5.84"**  
**90.68% Pervious = 5.164 ac    9.32% Impervious = 0.531 ac**

### Summary for Subcatchment P1:

Runoff = 17.11 cfs @ 12.16 hrs, Volume= 1.503 af, Depth= 5.95"

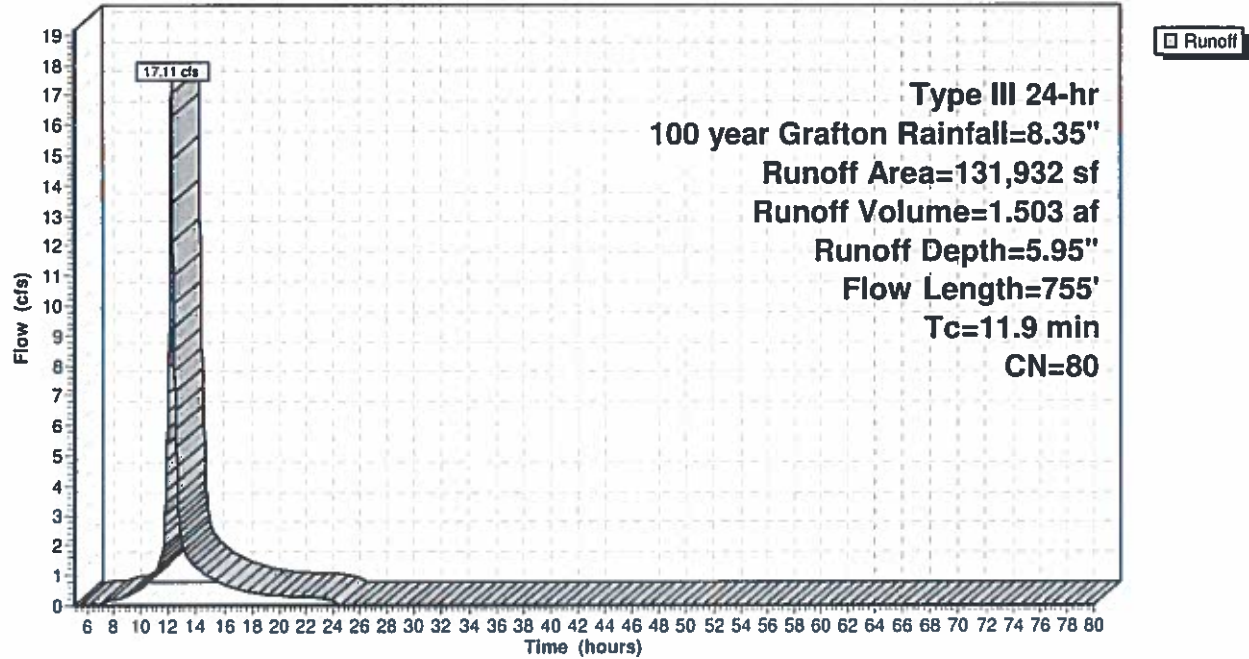
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
 Type III 24-hr 100 year Grafton Rainfall=8.35"

Area (sf)	CN	Description
14,710	73	Woods, Fair, HSG C
71,576	79	Pasture/grassland/range, Fair, HSG C
5,551	98	Roofs, HSG C
11,295	98	Paved parking, HSG C
3,800	89	Gravel roads, HSG C
25,000	74	>75% Grass cover, Good, HSG C
131,932	80	Weighted Average
115,086		87.23% Pervious Area
16,846		12.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	75	0.0340	0.22		<b>Sheet Flow, a-75'</b> Range n= 0.130 P2= 3.10"
2.1	225	0.0632	1.76		<b>Shallow Concentrated Flow, 75'-b</b> Short Grass Pasture Kv= 7.0 fps
3.4	375	0.0693	1.84		<b>Shallow Concentrated Flow, b-c</b> Short Grass Pasture Kv= 7.0 fps
0.7	80	0.0750	1.92		<b>Shallow Concentrated Flow, c-d</b> Short Grass Pasture Kv= 7.0 fps
11.9	755	Total			

**Subcatchment P1:**

Hydrograph



### Summary for Subcatchment P2:

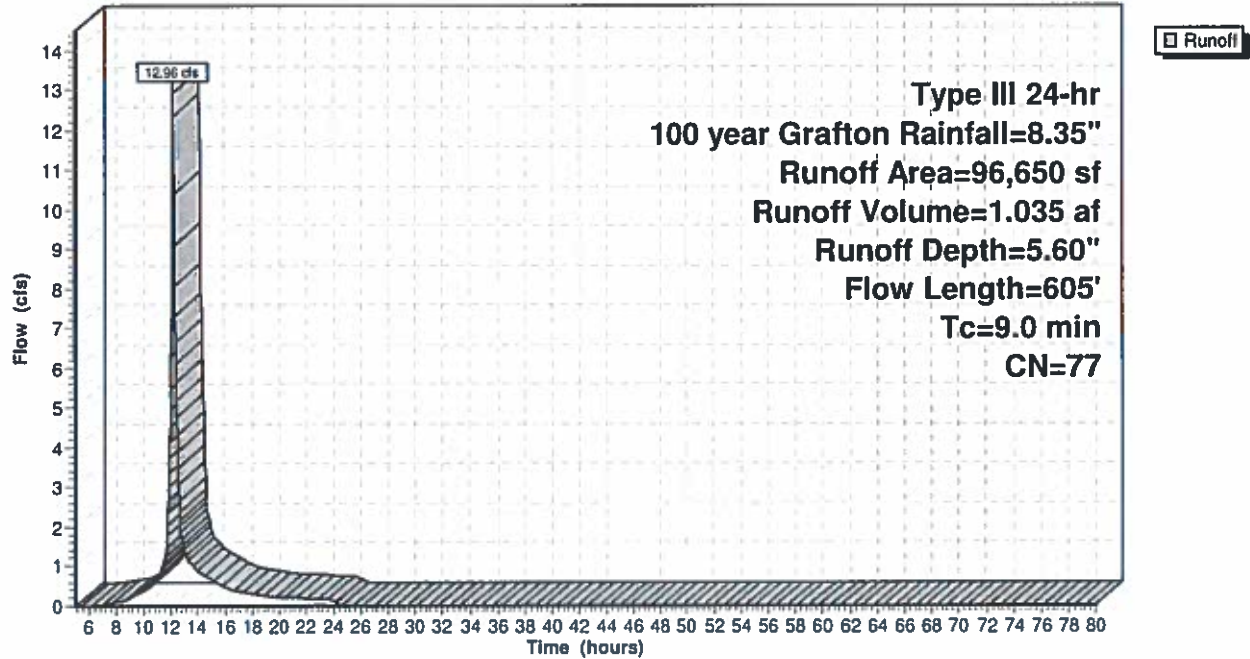
Runoff = 12.96 cfs @ 12.13 hrs, Volume= 1.035 af, Depth= 5.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
 Type III 24-hr 100 year Grafton Rainfall=8.35"

Area (sf)	CN	Description
23,923	73	Woods, Fair, HSG C
45,927	79	Pasture/grassland/range, Fair, HSG C
25,000	74	>75% Grass cover, Good, HSG C
1,800	98	Roofs, HSG C
96,650	77	Weighted Average
94,850		98.14% Pervious Area
1,800		1.86% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.0	75	0.0840	0.31		<b>Sheet Flow, a-75'</b> Range n= 0.130 P2= 3.10"
1.4	170	0.0810	1.99		<b>Shallow Concentrated Flow, 75'-b</b> Short Grass Pasture Kv= 7.0 fps
2.4	230	0.0500	1.57		<b>Shallow Concentrated Flow, b-c</b> Short Grass Pasture Kv= 7.0 fps
1.2	130	0.0650	1.78		<b>Shallow Concentrated Flow, c-d</b> Short Grass Pasture Kv= 7.0 fps
9.0	605	Total			

**Subcatchment P2:****Hydrograph**

### Summary for Subcatchment P3:

Runoff = 3.20 cfs @ 12.09 hrs, Volume= 0.235 af, Depth> 6.31"

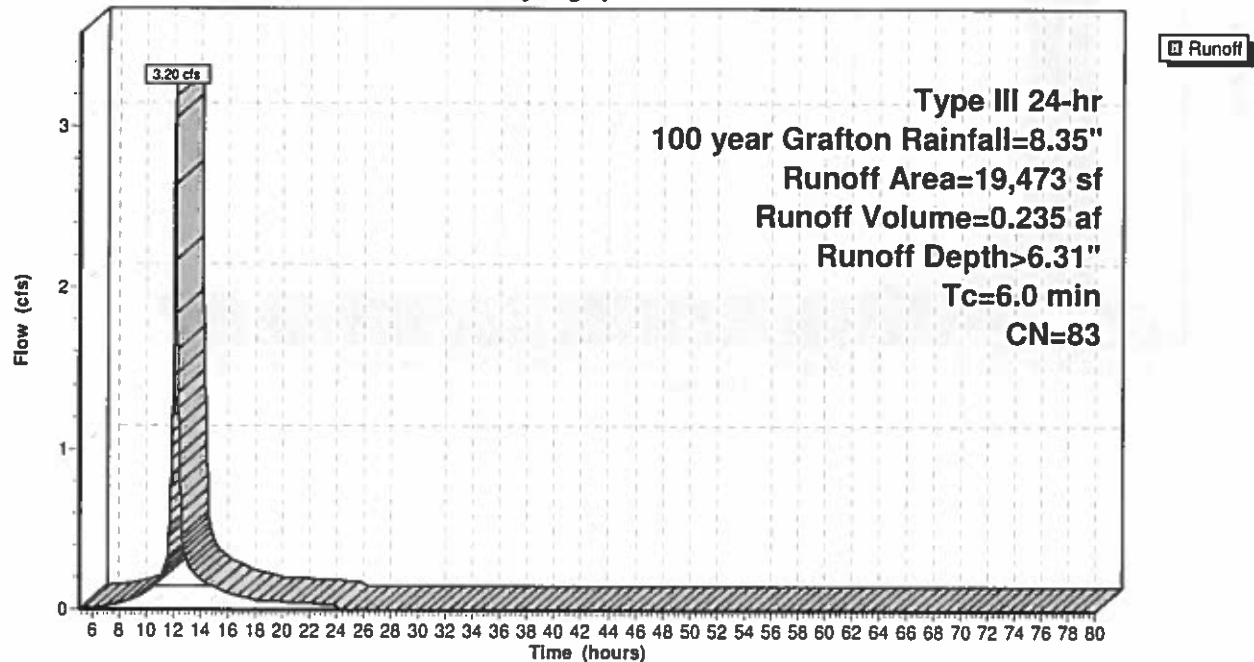
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs  
 Type III 24-hr 100 year Grafton Rainfall=8.35"

Area (sf)	CN	Description
14,993	79	Pasture/grassland/range, Fair, HSG C
4,480	98	Paved parking, HSG C
19,473	83	Weighted Average
14,993		76.99% Pervious Area
4,480		23.01% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry,

### Subcatchment P3:

Hydrograph



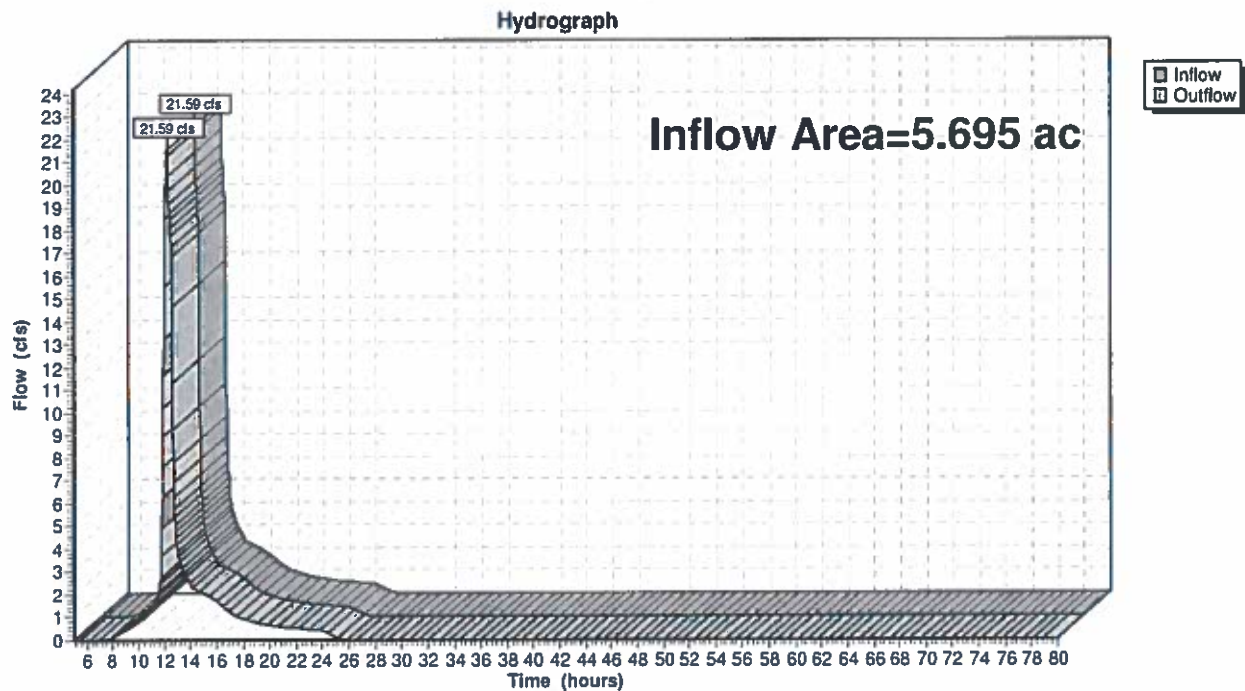
### Summary for Reach R1: EX Road Swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.695 ac, 9.32% Impervious, Inflow Depth > 5.77" for 100 year Grafton event  
Inflow = 21.59 cfs @ 12.27 hrs, Volume= 2.737 af  
Outflow = 21.59 cfs @ 12.27 hrs, Volume= 2.737 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs

### Reach R1: EX Road Swale





### Summary for Pond 1P:

Inflow Area = 5.248 ac, 8.16% Impervious, Inflow Depth = 5.80" for 100 year Grafton event  
 Inflow = 29.70 cfs @ 12.14 hrs, Volume= 2.537 af  
 Outflow = 20.20 cfs @ 12.28 hrs, Volume= 2.537 af, Atten= 32%, Lag= 8.2 min  
 Discarded = 0.02 cfs @ 12.28 hrs, Volume= 0.036 af  
 Primary = 18.51 cfs @ 12.28 hrs, Volume= 2.483 af  
 Secondary = 1.66 cfs @ 12.28 hrs, Volume= 0.018 af

Routing by Stor-Ind method, Time Span= 5.00-80.00 hrs, dt= 0.03 hrs / 3  
 Peak Elev= 395.98' @ 12.28 hrs Surf.Area= 6,138 sf Storage= 17,021 cf

Plug-Flow detention time= 38.9 min calculated for 2.537 af (100% of inflow)  
 Center-of-Mass det. time= 38.5 min ( 847.0 - 808.4 )

Volume	Invert	Avail.Storage	Storage Description
#1	392.00'	20,313 cf	<b>Custom Stage Data (Prismatic) Listed below (Recalc)</b>
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
392.00	1,105	0	0
393.00	3,725	2,415	2,415
394.00	4,505	4,115	6,530
395.00	5,263	4,884	11,414
396.00	6,153	5,708	17,122
396.50	6,609	3,191	20,313

Device	Routing	Invert	Outlet Devices
#1	Discarded	392.00'	<b>0.170 in/hr Exfiltration over Horizontal area</b> Conductivity to Groundwater Elevation = -2.50'
#2	Device 6	393.00'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#3	Device 6	392.50'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#4	Device 6	392.75'	<b>1.0" Vert. Orifice/Grate X 12.00</b> C= 0.600
#5	Device 6	394.10'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#6	Primary	390.50'	<b>18.0" Round Culvert</b> L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 390.50' / 390.00' S= 0.0100 ' / Cc= 0.900 n= 0.010, Flow Area= 1.77 sf
#7	Device 6	393.25'	<b>2.0" Vert. Orifice/Grate X 4.00</b> C= 0.600
#8	Device 6	392.35'	<b>1.5" Vert. Orifice/Grate X 8.00</b> C= 0.600
#9	Secondary	395.75'	<b>6.0' long x 8.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.43 2.54 2.70 2.69 2.68 2.68 2.66 2.64 2.64 2.64 2.65 2.65 2.66 2.66 2.68 2.70 2.74

**Discarded OutFlow** Max=0.02 cfs @ 12.28 hrs HW=395.98' (Free Discharge)

↳1=Exfiltration ( Controls 0.02 cfs)

**Primary OutFlow** Max=18.51 cfs @ 12.28 hrs HW=395.98' (Free Discharge)

↳6=Culvert (Inlet Controls 18.51 cfs @ 10.47 fps)

↳2=Orifice/Grate (Passes < 0.54 cfs potential flow)

↳3=Orifice/Grate (Passes < 0.58 cfs potential flow)

↳4=Orifice/Grate (Passes < 0.56 cfs potential flow)

↳5=Orifice/Grate (Passes < 20.74 cfs potential flow)

↳7=Orifice/Grate (Passes < 0.68 cfs potential flow)

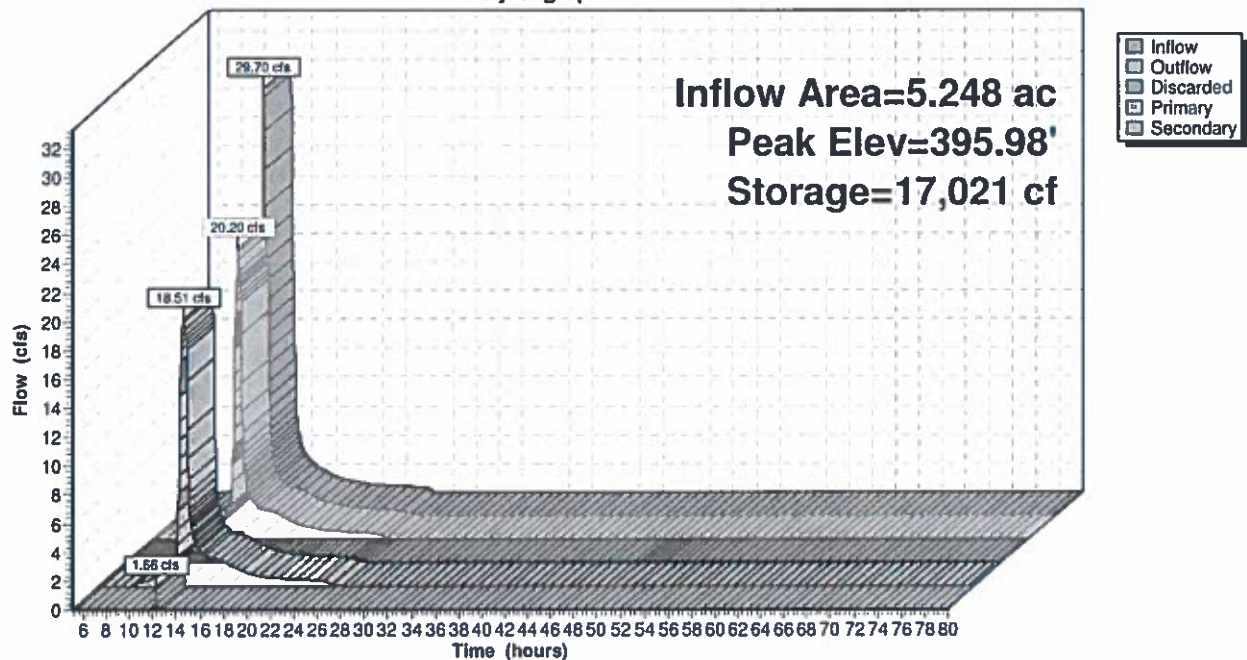
↳8=Orifice/Grate (Passes < 0.89 cfs potential flow)

**Secondary OutFlow** Max=1.62 cfs @ 12.28 hrs HW=395.98' (Free Discharge)

↳9=Broad-Crested Rectangular Weir (Weir Controls 1.62 cfs @ 1.17 fps)

### Pond 1P:

#### Hydrograph



## APPENDIX 3

### DEP STORMWATER MANAGEMENT STANDARDS



# Checklist for Stormwater Report

## A. Introduction

**Important:** When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.



A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.<sup>1</sup> This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8<sup>2</sup>
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

<sup>1</sup> The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

<sup>2</sup> For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.



Massachusetts Department of Environmental Protection  
Bureau of Resource Protection - Wetlands Program

## Checklist for Stormwater Report

### B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

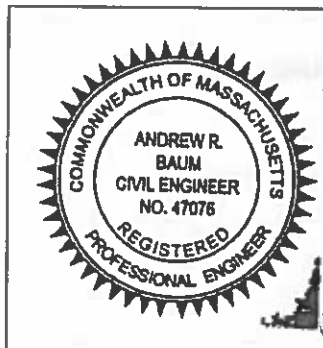
*Note:* Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

### Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature



Signature and Date

### Checklist

**Project Type:** Is the application for new development, redevelopment, or a mix of new and redevelopment?

- ☐ New development
- ☐ Redevelopment
- ☒ Mix of New Development and Redevelopment



# Checklist for Stormwater Report

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## Checklist (continued)

**LID Measures:** Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- ☒ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☐ Reduced Impervious Area (Redevelopment Only)
- ☐ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☒ Use of "country drainage" versus curb and gutter conveyance and pipe
- ☐ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☒ Grass Channel
- ☐ Green Roof
- ☒ Other (describe): Infiltration Basin

## Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges
- ☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.



# Checklist for Stormwater Report

## Checklist (continued)

### Standard 2: Peak Rate Attenuation

- ☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
- ☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.
- ☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

### Standard 3: Recharge

- ☒ Soil Analysis provided.
- ☒ Required Recharge Volume calculation provided.
- ☐ Required Recharge volume reduced through use of the LID site Design Credits.
- ☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.
  - ☒ Static
  - ☐ Simple Dynamic
  - ☐ Dynamic Field<sup>1</sup>
- ☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.
- ☒ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.
- ☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
- ☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:
  - ☒ Site is comprised solely of C and D soils and/or bedrock at the land surface
  - ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
  - ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
  - ☒ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.
- ☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.
- ☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

<sup>1</sup> 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.





# Checklist for Stormwater Report

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## Checklist (continued)

### Standard 3: Recharge (continued)

- ☒ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.
- ☒ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

### Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
  - Provisions for storing materials and waste products inside or under cover;
  - Vehicle washing controls;
  - Requirements for routine inspections and maintenance of stormwater BMPs;
  - Spill prevention and response plans;
  - Provisions for maintenance of lawns, gardens, and other landscaped areas;
  - Requirements for storage and use of fertilizers, herbicides, and pesticides;
  - Pet waste management provisions;
  - Provisions for operation and management of septic systems;
  - Provisions for solid waste management;
  - Snow disposal and plowing plans relative to Wetland Resource Areas;
  - Winter Road Salt and/or Sand Use and Storage restrictions;
  - Street sweeping schedules;
  - Provisions for prevention of illicit discharges to the stormwater management system;
  - Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
  - Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
  - List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.
- ☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.
  - ☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:
    - ☐ is within the Zone II or Interim Wellhead Protection Area
    - ☐ is near or to other critical areas
    - ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
    - ☐ involves runoff from land uses with higher potential pollutant loads.
  - ☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.
  - ☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.





# Checklist for Stormwater Report

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## Checklist (continued)

### Standard 4: Water Quality (continued)

- ☒ The BMP is sized (and calculations provided) based on:
  - ☒ The ½" or 1" Water Quality Volume or
  - ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.
- ☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.
- ☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

### Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

- ☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.
- ☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted *prior to* the discharge of stormwater to the post-construction stormwater BMPs.
- ☒ The NPDES Multi-Sector General Permit does *not* cover the land use.
- ☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.
- ☐ All exposure has been eliminated.
- ☐ All exposure has *not* been eliminated and all BMPs selected are on MassDEP LUHPPL list.
- ☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

### Standard 6: Critical Areas

- ☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.
- ☐ Critical areas and BMPs are identified in the Stormwater Report.



# Checklist for Stormwater Report

## Checklist (continued)

### Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

- ☒ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:
- ☐ Limited Project
  - ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
  - ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
  - ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
  - ☐ Bike Path and/or Foot Path
  - ☐ Redevelopment Project
  - ☒ Redevelopment portion of mix of new and redevelopment.
- ☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.
- ☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

### Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
  - Construction Period Operation and Maintenance Plan;
  - Names of Persons or Entity Responsible for Plan Compliance;
  - Construction Period Pollution Prevention Measures;
  - Erosion and Sedimentation Control Plan Drawings;
  - Detail drawings and specifications for erosion control BMPs, including sizing calculations;
  - Vegetation Planning;
  - Site Development Plan;
  - Construction Sequencing Plan;
  - Sequencing of Erosion and Sedimentation Controls;
  - Operation and Maintenance of Erosion and Sedimentation Controls;
  - Inspection Schedule;
  - Maintenance Schedule;
  - Inspection and Maintenance Log Form.
- ☐ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.



# Checklist for Stormwater Report

## Checklist (continued)

### Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

- ☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has **not** been included in the Stormwater Report but will be submitted **before** land disturbance begins.
- ☐ The project is **not** covered by a NPDES Construction General Permit.
- ☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.
- ☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted **BEFORE** land disturbance begins.

### Standard 9: Operation and Maintenance Plan

- ☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:
  - ☒ Name of the stormwater management system owners;
  - ☒ Party responsible for operation and maintenance;
  - ☒ Schedule for implementation of routine and non-routine maintenance tasks;
  - ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
  - ☐ Description and delineation of public safety features;
  - ☐ Estimated operation and maintenance budget; and
  - ☒ Operation and Maintenance Log Form.
- ☒ The responsible party is **not** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:
  - ☒ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
  - ☒ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

### Standard 10: Prohibition of Illicit Discharges

- ☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;
- ☐ An Illicit Discharge Compliance Statement is attached;
- ☒ NO Illicit Discharge Compliance Statement is attached but will be submitted **prior to** the discharge of any stormwater to post-construction BMPs.

## **APPENDIX 4**

### **RECHARGE TO GROUNDWATER**

The prescribed stormwater runoff volume to be recharged to groundwater has been determined by using the method described in the Massachusetts DEP Stormwater Policy Handbook. The amount of recharge volume is related to the soil type as identified from site exploration and the total net increase in impervious area for re-development and is defined in the following table:

<u>Hydrologic Group</u>	<u>Volume to Recharge (x Total Impervious Area)</u>
A	0.60 inches of runoff
B	0.35 inches of runoff
C	0.25 inches of runoff
D	waived

Existing Impervious Area: Catchment "P1, P2 & P3"

Roof Top:	3,751 SqFt
Pavement:	<u>6,795 SqFt</u>
Total Impervious Area	10,546 SqFt

Proposed Impervious Area: Catchment "P1, P2 & P3"

Roof Top:	7,351 SqFt
Pavement:	<u>15,775 SqFt</u>
Total Impervious Area	23,126 SqFt

Net Increase in Impervious Area Calculations:

$$23,126 - 10,546 \text{ SqFt} = 12,580 \text{ SqFt}$$

Recharge Calculation:

$$\begin{aligned} \text{Recharge} &= \text{Impervious Area} \times 0.25 \text{ inches} \\ &= 12,580 \text{ SqFt} \times 0.25 \text{ inches} \\ &= 262 \text{ Cubic Feet of Runoff (Redevelopment)} \end{aligned}$$

A minimum storage volume to 550.5 cubic feet has been provided in detention pond "1P" below elevation 392.35'. The volume of water will infiltrate recharging the groundwater in less than 72 hours.

**APPENDIX 5**  
**REMOVAL OF 80% TSS**

The runoff volume to be treated for water quality is calculated as 0.5 inches of runoff times the total impervious area of the post-development project site.

**Volume Requiring Treatment:**

Impervious Area: 23,126 SqFt (From Above)

$$\begin{aligned}\text{Volume} &= 23,126 \text{ SqFt} \times 0.5 \text{ inches} \\ &= 965 \text{ Cubic Feet}\end{aligned}$$

The 80% removal standard is assumed to be met by providing best management practices (BMPs). The State DEP has developed effective removal rates for typical BMPs. The removal rates for BMPs utilized in the project are indicated below:

BMP	TSS Removal Rate
Infiltration Basin with Water Quality Swale Pretreatment	80%

The proposed BMP provides treatment to a minimum of 80% of the required water quality volume. The removal rate and treatment method for each sub-catchment area is summarized in the following table. This table shows that the minimum goal of 80% reduction is met for all sub-catchment areas.

**Site TSS Treatment**

Sub-basin	BMP	Removal Rate
1P	Infiltration Basin	80% Removal

Averaging of removal rates is acceptable when all discharges are within the same sub-basin.

**INSTRUCTIONS:**

1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Meadowbrook Manor, Grafton, MA

B BMP <sup>1</sup>	C TSS Removal Rate <sup>1</sup>	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Infiltration Basin	0.80	1.00	0.80	0.20
	0.00	0.20	0.00	0.20
	0.00	0.20	0.00	0.20
	0.00	0.20	0.00	0.20
	0.00	0.20	0.00	0.20

Separate Form Needs to be Completed for Each Outlet or BMP Train

**Total TSS Removal =**

Project:	18-102
Prepared By:	S. Bressette
Date:	5/7/2019

\*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet  
must be used if Proprietary BMP Proposed

1. From MassDEP Stormwater Handbook Vol. 1



## APPENDIX 6

### OPERATION/MAINTENANCE PLAN

## **OPERATION/MAINTENANCE PLAN MEADOWBROOK MANOR, GRAFTON, MASSACHUSETTS**

This plan has been designed to address both the construction and post-development operation and maintenance of the stormwater management controls for the commercial building. The plan addresses and identifies the following areas:

- Stormwater Management System Owner
- Party Responsible for Operation/Maintenance
- Schedule for Inspection and Maintenance
- Routine and Non-Routine Maintenance Tasks

### **Stormwater Management System Owner**

The Home Owner's Association will maintain ownership of the stormwater management system.

### **Party Responsible For Operation/Maintenance**

The developer/general contractor will be responsible for the operation and maintenance of the stormwater management system until acceptance by the Town. After acceptance, the Home Owner's Association will be responsible for the operation and maintenance of the stormwater management system.

### **Schedule For Inspection And Maintenance**

The inspection schedule and maintenance requirements for each structural BMP utilized in the site stormwater management system is indicated below:

Grassed Swales: Grassed swales shall be mowed regularly and kept free of debris.  
Stressed vegetation shall be re-seeded when coverage is less than 80%.  
Inspection/removal of sediment accumulation shall be performed semi-annually.

Detention Basins: Detention basins should be inspected at least once per year to ensure that the basin is operating as intended. Inspections should be conducted during wet weather to determine if the basin is meeting the targeted detention times.

### **Routine And Non-Routine Maintenance Tasks**

Routine and non-routine maintenance tasks for each structural BMP utilized are outlined below:

Detention Basins: Remove and properly dispose of all sediment and hydrocarbons in accordance with local, state, and federal guidelines and regulations. Sediment should be removed from the basin as necessary, and at least once every 10 years.

## APPENDIX 7

### SUPPORTING TABLES AND COMPUTATIONS

1011	0		100
1012	0		100
1013	0		100
1014	0		100
1015	0		100
1016	0		100
1017	0		100
1018	0		100
1019	0		100
1020	0		100
1021	0		100
1022	0		100
1023	0		100
1024	0		100
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1028	0		100
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1030	0		100
1031	0		100
1032	0		100
1033	0		100
1034	0		100
1035	0		100
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1037	0		100
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1077	0		100
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1079	0		100
1080	0		100
1081	0		100
1082	0		100
1083	0		100
1084	0		100
1085	0		100
1086	0		100
1087	0		100
1088	0		100
1089	0		100
1090	0		100
1091	0		100
1092	0		100
1093	0		100
1094	0		100
1095	0		100
1096	0		100
1097	0		100
1098	0		100
1099	0		100
1100	0		100

**Stage-Area-Storage for Pond 1P:**

Elevation (feet)	Surface (sq-ft)	Horizontal (sq-ft)	Storage (cubic-feet)
392.00	1,105	1,105	0
392.10	1,367	1,367	124
392.20	1,629	1,629	273
392.30	1,891	1,891	449
392.40	2,153	2,153	652
392.50	2,415	2,415	880
392.60	2,677	2,677	1,135
392.70	2,939	2,939	1,415
392.80	3,201	3,201	1,722
392.90	3,463	3,463	2,056
393.00	3,725	3,725	2,415
393.10	3,803	3,803	2,791
393.20	3,881	3,881	3,176
393.30	3,959	3,959	3,568
393.40	4,037	4,037	3,967
393.50	4,115	4,115	4,375
393.60	4,193	4,193	4,790
393.70	4,271	4,271	5,214
393.80	4,349	4,349	5,645
393.90	4,427	4,427	6,083
394.00	4,505	4,505	6,530
394.10	4,581	4,581	6,984
394.20	4,657	4,657	7,446
394.30	4,732	4,732	7,916
394.40	4,808	4,808	8,393
394.50	4,884	4,884	8,877
394.60	4,960	4,960	9,369
394.70	5,036	5,036	9,869
394.80	5,111	5,111	10,377
394.90	5,187	5,187	10,891
395.00	5,263	5,263	11,414
395.10	5,352	5,352	11,945
395.20	5,441	5,441	12,484
395.30	5,530	5,530	13,033
395.40	5,619	5,619	13,590
395.50	5,708	5,708	14,157
395.60	5,797	5,797	14,732
395.70	5,886	5,886	15,316
395.80	5,975	5,975	15,909
395.90	6,064	6,064	16,511
396.00	6,153	6,153	17,122
396.10	6,244	6,244	17,742
396.20	6,335	6,335	18,371
396.30	6,427	6,427	19,009
396.40	6,518	6,518	19,656
396.50	6,609	6,609	20,313

} 550.5 @ 392.35'

**18-102\_Meadowbrook\_PROP Revised 5.8.19**    *Type III 24-hr 100 year Grafton Rainfall=8.35"*

Prepared by S. Bressette

Printed 5/13/19

HydroCAD® 10.00-20 s/n 03092 © 2017 HydroCAD Software Solutions LLC

**Hydrograph for Pond 1P:**

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)	Secondary (cfs)
5.00	0.00	0	392.00	0.00	0.00	0.00	0.00
6.50	0.06	88	392.07	0.01	0.01	0.00	0.00
8.00	0.26	789	392.46	0.11	0.01	0.10	0.00
9.50	0.73	1,705	392.79	0.49	0.01	0.48	0.00
11.00	1.76	3,692	393.33	1.19	0.02	1.18	0.00
12.50	10.40	13,869	395.45	17.46	0.02	17.44	0.00
14.00	2.12	7,158	394.14	2.28	0.02	2.26	0.00
15.50	1.36	5,588	393.79	1.79	0.02	1.78	0.00
17.00	0.89	3,520	393.29	1.12	0.02	1.11	0.00
18.50	0.63	2,475	393.02	0.76	0.01	0.74	0.00
20.00	0.54	1,987	392.88	0.61	0.01	0.60	0.00
21.50	0.47	1,732	392.80	0.50	0.01	0.49	0.00
23.00	0.40	1,579	392.75	0.43	0.01	0.42	0.00
24.50	0.00	1,042	392.56	0.24	0.01	0.23	0.00
26.00	0.00	600	392.38	0.02	0.01	0.01	0.00
27.50	0.00	541	392.35	0.01	0.01	0.00	0.00
29.00	0.00	499	392.33	0.01	0.01	0.00	0.00
30.50	0.00	458	392.30	0.01	0.01	0.00	0.00
32.00	0.00	418	392.28	0.01	0.01	0.00	0.00
33.50	0.00	380	392.26	0.01	0.01	0.00	0.00
35.00	0.00	342	392.24	0.01	0.01	0.00	0.00
36.50	0.00	306	392.22	0.01	0.01	0.00	0.00
38.00	0.00	271	392.20	0.01	0.01	0.00	0.00
39.50	0.00	237	392.18	0.01	0.01	0.00	0.00
41.00	0.00	204	392.16	0.01	0.01	0.00	0.00
42.50	0.00	172	392.13	0.01	0.01	0.00	0.00
44.00	0.00	142	392.11	0.01	0.01	0.00	0.00
45.50	0.00	113	392.09	0.01	0.01	0.00	0.00
47.00	0.00	85	392.07	0.01	0.01	0.00	0.00
48.50	0.00	58	392.05	0.00	0.00	0.00	0.00
50.00	0.00	36	392.03	0.00	0.00	0.00	0.00
51.50	0.00	22	392.02	0.00	0.00	0.00	0.00
53.00	0.00	13	392.01	0.00	0.00	0.00	0.00
54.50	0.00	8	392.01	0.00	0.00	0.00	0.00
56.00	0.00	5	392.00	0.00	0.00	0.00	0.00
57.50	0.00	3	392.00	0.00	0.00	0.00	0.00
59.00	0.00	2	392.00	0.00	0.00	0.00	0.00
60.50	0.00	1	392.00	0.00	0.00	0.00	0.00
62.00	0.00	1	392.00	0.00	0.00	0.00	0.00
63.50	0.00	0	392.00	0.00	0.00	0.00	0.00
65.00	0.00	0	392.00	0.00	0.00	0.00	0.00
66.50	0.00	0	392.00	0.00	0.00	0.00	0.00
68.00	0.00	0	392.00	0.00	0.00	0.00	0.00
69.50	0.00	0	392.00	0.00	0.00	0.00	0.00
71.00	0.00	0	392.00	0.00	0.00	0.00	0.00
72.50	0.00	0	392.00	0.00	0.00	0.00	0.00
74.00	0.00	0	392.00	0.00	0.00	0.00	0.00
75.50	0.00	0	392.00	0.00	0.00	0.00	0.00
77.00	0.00	0	392.00	0.00	0.00	0.00	0.00
78.50	0.00	0	392.00	0.00	0.00	0.00	0.00
80.00	0.00	0	392.00	0.00	0.00	0.00	0.00

## RIP-RAP SIZING

$$\text{GIVEN: } Q_{100} = 18.5 \text{ cfs} \quad D_{\phi} = 18''$$

$$\text{Try } d_{\phi} = 0.5 D_{\phi} = \frac{18}{2} = \frac{9}{12} = 0.75 \text{ ft}$$

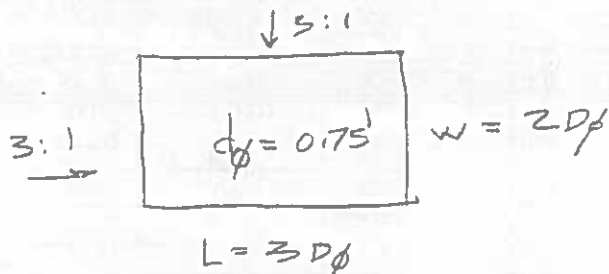
$$\text{for } d_{\phi} = 0.5 D_{\phi} \text{ USE } C = 0.0125$$

$$d_{50} = C (D_{\phi}^2 / TW) (Q / D_{\phi}^{5/2})^{4/3}$$

$$TW = \frac{18}{2} \left( \frac{1}{12} \right) = 0.75 \text{ ft}$$

$$d_{50} = 0.0125 \left( \frac{1.5^2}{0.75} \right) \left( \frac{18.5}{1.5^{5/2}} \right)^{4/3}$$

$$d_{50} = 0.0125 (3) (12.66) = 0.475 \text{ ft} \quad \text{USE } d_{50} = 6''$$



$$\begin{aligned} \text{SURFACE AREA} &= (L + 2(3d_{\phi}^2 + d_{\phi}^2)^{1/2})(W + 2(3d_{\phi}^2 + d_{\phi}^2)^{1/2}) \\ &= (4.5 + 2(2.37))(3 + 2(2.37)) \\ &= (9.2)(7.8) = 71.8 \text{ ft}^2 \end{aligned}$$

$$V = \text{SURFACE AREA} \times \text{DEPTH} \quad \text{DEPTH} = 2(d_{50})$$

$$V = 71.8 \text{ ft}^2 \left( \frac{6''(2)}{12''/\text{ft}} \right) = 71.8 \text{ ft}^3 / 27 \text{ ft}^3/\text{CY} = 2.65 \text{ CY}$$

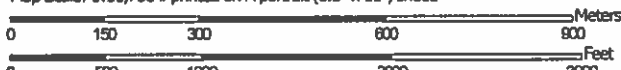
$$\text{WEIGHT} = 2.65 \text{ CY} (1.5 \text{ TN/CY}) = 4 \text{ TONS } d_{50} = 6'' \text{ STONE}$$



# Soil Map—Worcester County, Massachusetts, Southern Part



Map Scale: 1:11,700 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84



Natural Resources  
Conservation Service

Web Soil Survey  
National Cooperative Soil Survey

1/29/2019  
Page 1 of 3



## MAP LEGEND

	Area of Interest (AOI)		Soil Area
	Soils		Stony Spot
	Soil Map Unit Polygons		Very Stony Spot
	Soil Map Unit Lines		Wet Spot
	Soil Map Unit Points		Other
	Special Point Features		Special Line Features
	Blowout		
	Borrow Pit		
	Clay Spot		
	Closed Depression		
	Gravel Pit		
	Gravelly Spot		
	Landfill		
	Lava Flow		
	Marsh or swamp		
	Mine or Quarry		
	Miscellaneous Water		
	Perennial Water		
	Rock Outcrop		
	Saline Spot		
	Sandy Spot		
	Severely Eroded Spot		
	Sinkhole		
	Slide or Slip		
	Sodic Spot		
			Water Features
			Streams and Canals
			Transportation
			Rails
			Interstate Highways
			US Routes
			Major Roads
			Local Roads
			Background
			Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

**Warning:** Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
Web Soil Survey URL:  
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Worcester County, Massachusetts, Southern Part

Survey Area Data: Version 11, Sep 11, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 12, 2014—Sep 28, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	0.3	0.0%
52A	Freetown muck, 0 to 1 percent slopes	75.5	10.8%
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony	18.5	2.7%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	18.5	2.7%
102C	Chatfield-Hollis-Rock outcrop complex, 0 to 15 percent slopes	6.1	0.9%
102E	Chatfield-Hollis-Rock outcrop complex, 15 to 35 percent slopes	7.0	1.0%
245C	Hinckley loamy sand, 8 to 15 percent slopes	23.7	3.4%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	18.3	2.6%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	44.4	6.4%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	101.9	14.6%
307C	Paxton fine sandy loam, 8 to 15 percent slopes, extremely stony	67.9	9.7%
307E	Paxton fine sandy loam, 15 to 35 percent slopes, extremely stony	71.9	10.3%
310A	Woodbridge fine sandy loam, 0 to 3 percent slopes	0.3	0.0%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	194.9	28.0%
312B	Woodbridge fine sandy loam, 0 to 8 percent slopes, extremely stony	14.8	2.1%
422B	Canton fine sandy loam, 0 to 8 percent slopes, extremely stony	12.9	1.9%
422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony	4.3	0.6%
651	Udorthents, smoothed	15.3	2.2%
<b>Totals for Area of Interest</b>		<b>696.4</b>	<b>100.0%</b>

## Worcester County, Massachusetts, Southern Part

### 310B—Woodbridge fine sandy loam, 3 to 8 percent slopes

#### Map Unit Setting

*National map unit symbol:* 2t2ql

*Elevation:* 0 to 1,470 feet

*Mean annual precipitation:* 36 to 71 inches

*Mean annual air temperature:* 39 to 55 degrees F

*Frost-free period:* 140 to 240 days

*Farmland classification:* All areas are prime farmland

#### Map Unit Composition

*Woodbridge, fine sandy loam, and similar soils:* 82 percent

*Minor components:* 18 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Woodbridge, Fine Sandy Loam

##### Setting

*Landform:* Hills, drumlins, ground moraines

*Landform position (two-dimensional):* Backslope, footslope, summit

*Landform position (three-dimensional):* Side slope

*Down-slope shape:* Concave

*Across-slope shape:* Linear

*Parent material:* Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

##### Typical profile

*Ap - 0 to 7 inches:* fine sandy loam

*Bw1 - 7 to 18 inches:* fine sandy loam

*Bw2 - 18 to 30 inches:* fine sandy loam

*Cd - 30 to 65 inches:* gravelly fine sandy loam

##### Properties and qualities

*Slope:* 3 to 8 percent

*Depth to restrictive feature:* 20 to 39 inches to densic material

*Natural drainage class:* Moderately well drained

*Runoff class:* Medium

*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.14 in/hr)

*Depth to water table:* About 18 to 30 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Salinity, maximum in profile:* Nonsaline (0.0 to 1.9 mmhos/cm)

*Available water storage in profile:* Low (about 3.6 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 2w

*Hydrologic Soil Group:* C/D

*Hydric soil rating:* No

### Minor Components

#### Paxton

*Percent of map unit:* 10 percent

*Landform:* Hills, ground moraines, drumlins

*Landform position (two-dimensional):* Summit, shoulder, backslope

*Landform position (three-dimensional):* Side slope, crest, nose  
slope

*Down-slope shape:* Convex, linear

*Across-slope shape:* Convex

*Hydric soil rating:* No

#### Ridgebury

*Percent of map unit:* 8 percent

*Landform:* Ground moraines, depressions, drainageways, hills

*Landform position (two-dimensional):* Toeslope, backslope,  
footslope

*Landform position (three-dimensional):* Base slope, head slope, dip

*Down-slope shape:* Concave

*Across-slope shape:* Concave

*Hydric soil rating:* Yes

## Data Source Information

Soil Survey Area: Worcester County, Massachusetts, Southern Part

Survey Area Data: Version 11, Sep 11, 2018

## Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

### A. Facility Information

Bob Flynn  
Owner Name

15 Meadowbrook - Lot 1 Drainage Basin  
Street Address

Grafton  
City

MA  
State

Lot 1  
Map/Lot #  
01519  
Zip Code

### B. Site Information

1. (Check one) ☒ New Construction ☐ Upgrade ☐ Repair

2. Soil Survey Available? ☒ Yes ☐ No

If yes: USDA Web Soil Survey Source 310B  
Soil Map Unit

Woodbridge fine sandy loam  
Soil Name

Few  
Soil Limitations  
Hill  
Landform

3. Surficial Geological Report Available? ☐ Yes ☒ No

If yes: Year Published/Source Publication Scale Map Unit

4. Flood Rate Insurance Map

Above the 500-year flood boundary? ☒ Yes ☐ No  
If Yes, continue to #5.

Within the 100-year flood boundary? ☐ Yes ☒ No

5. Within a velocity zone? ☐ Yes ☒ No

6. Within a Mapped Wetland Area? ☐ Yes ☒ No

MassGIS Wetland Data Layer.

Wetland Type

7. Current Water Resource Conditions (USGS):  
Month/Year

Range: ☐ Above Normal ☐ Normal ☐ Below Normal

8. Other references reviewed:

Commonwealth of Massachusetts  
City/Town of Grafton

**Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal**

**C. On-Site Review** *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: 818-9 Date: 8/23/18 Time: 12:00 PM Weather: Sunny- 70

1. Location

Ground Elevation at Surface of Hole: 391 feet Latitude/Longitude: 42°12'31" / 71°40'40"

Description of Location: See Septic Plan

2. Land Use Horse Pasture (e.g., woodland, agricultural field, vacant lot, etc.) Very Few Surface Stones (e.g., cobbles, stones, boulders, etc.) 3333333 Slope (%) 3-8

Grass Vegetation Hill Landform SH Position on Landscape (SU, SH, BS, FS, TS) 80 feet

3. Distances from: Open Water Body >150 feet Drainage Way >150 feet Wetlands 80 feet

Property Line 60 feet Drinking Water Well >150 feet Other 80 feet

4. Parent Material: Coarse loamy melt out till derived from granite Unsuitable Materials Present: ☐ Yes ☒ No

If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐

5. Groundwater Observed: ☒ Yes ☐ No If yes: 60 Depth Weeping from Pit Depth Standing Water in Hole

Estimated Depth to High Groundwater: 48 inches 387 elevation

**C. On-Site Review (continued)**

Commonwealth of Massachusetts  
City/Town of Grafton

**Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal**

Deep Observation Hole Number: 818-9

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color- Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume			Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones				
0-12	A	10YR 3/3	None			SL	0	0		Massive	Friable	
12-30	Bw	10YR 6/6	None			SL	5	5		Single grained	Friable	
30-60	C	2.5Y 7/2	48"			SL	40	5		Single grained	Friable	Gravel
												Weep @ 60"

Additional Notes:

**C. On-Site Review (continued)**

Deep Observation Hole Number:

Date Time Weather

Commonwealth of Massachusetts  
City/Town of Grafton

**Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal**

1. Location

Ground Elevation at Surface of Hole: \_\_\_\_\_ feet      Latitude/Longitude: \_\_\_\_\_ / \_\_\_\_\_

2. Land Use

(e.g., woodland, agricultural field, vacant lot, etc.) \_\_\_\_\_ Surface Stones (e.g., cobbles, stones, boulders, etc.) \_\_\_\_\_ Slope (%) \_\_\_\_\_

Vegetation

3. Distances from:

Open Water Body \_\_\_\_\_ feet

Property Line \_\_\_\_\_ feet

Landform

Drainage Way \_\_\_\_\_ feet

Drinking Water Well \_\_\_\_\_ feet

Position on Landscape (SU, SH, BS, FS, TS)

Wetlands \_\_\_\_\_ feet

Other \_\_\_\_\_ feet

4. Parent Material:

If Yes: ☐ Disturbed Soil  
Bedrock

☐ Fill Material

☐ Impervious Layer(s)

☐ Weathered/Fractured Rock

Groundwater Observed: ☐ Yes ☐ No

Unsuitable Materials Present: ☐ Yes ☐ No

If yes:

Depth Weeping from Pit \_\_\_\_\_ Depth Standing Water in Hole \_\_\_\_\_

Estimated Depth to High Groundwater:

\_\_\_\_\_ inches      \_\_\_\_\_ elevation

**C. On-Site Review (continued)**

Deep Observation Hole Number: \_\_\_\_\_

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color- Moist (Munsell)	Redoximorphic Features	Soil Texture (USDA)	Coarse Fragments (% by volume)	Soil Structure	Other
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## Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

[illegible]

#### D. Determination of High Groundwater Elevation

1. Method Used:
- ☐ Depth observed standing water in observation hole
- ☐ Depth weeping from side of observation hole

Obs. Hole # 818-9 Obs. Hole #       

inches \_\_\_\_\_ inches \_\_\_\_\_

inches	inches

## Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

- ☒ Depth to soil redoximorphic features (mottles) 48 inches
- ☐ Depth to adjusted seasonal high groundwater ( $S_h$ ) (USGS methodology) inches

Index Well Number \_\_\_\_\_ Reading Date \_\_\_\_\_

$$S_h = S_c - [S_r \times (OW_c - OW_{max}) / OW_r]$$

Obs. Hole #	_____	$S_c$	_____	$S_r$	_____	$OW_c$	_____	$OW_{max}$	_____	$OW_r$	_____	$S_h$	_____
Obs. Hole #	_____	$S_c$	_____	$S_r$	_____	$OW_c$	_____	$OW_{max}$	_____	$OW_r$	_____	$S_h$	_____

### E. Depth of Pervious Material

#### 1. Depth of Naturally Occurring Pervious Material

- a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system?

☐ Yes ☐ No

- b. If yes, at what depth was it observed?

Upper boundary: \_\_\_\_\_ inches

Lower boundary: \_\_\_\_\_ inches

- c. If no, at what depth was impervious material observed?

Upper boundary: \_\_\_\_\_ inches

Lower boundary: \_\_\_\_\_ inches

### F. Board of Health Witness

N/A

Name of Board of Health Witness

Board of Health

### G. Soil Evaluator Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience

Commonwealth of Massachusetts  
City/Town of Grafton

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described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

N/A

Signature of Soil Evaluator

Date

Typed or Printed Name of Soil Evaluator / License #

Expiration Date of License

**Note:** In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

**Field Diagrams**

Use this sheet for field diagrams:

